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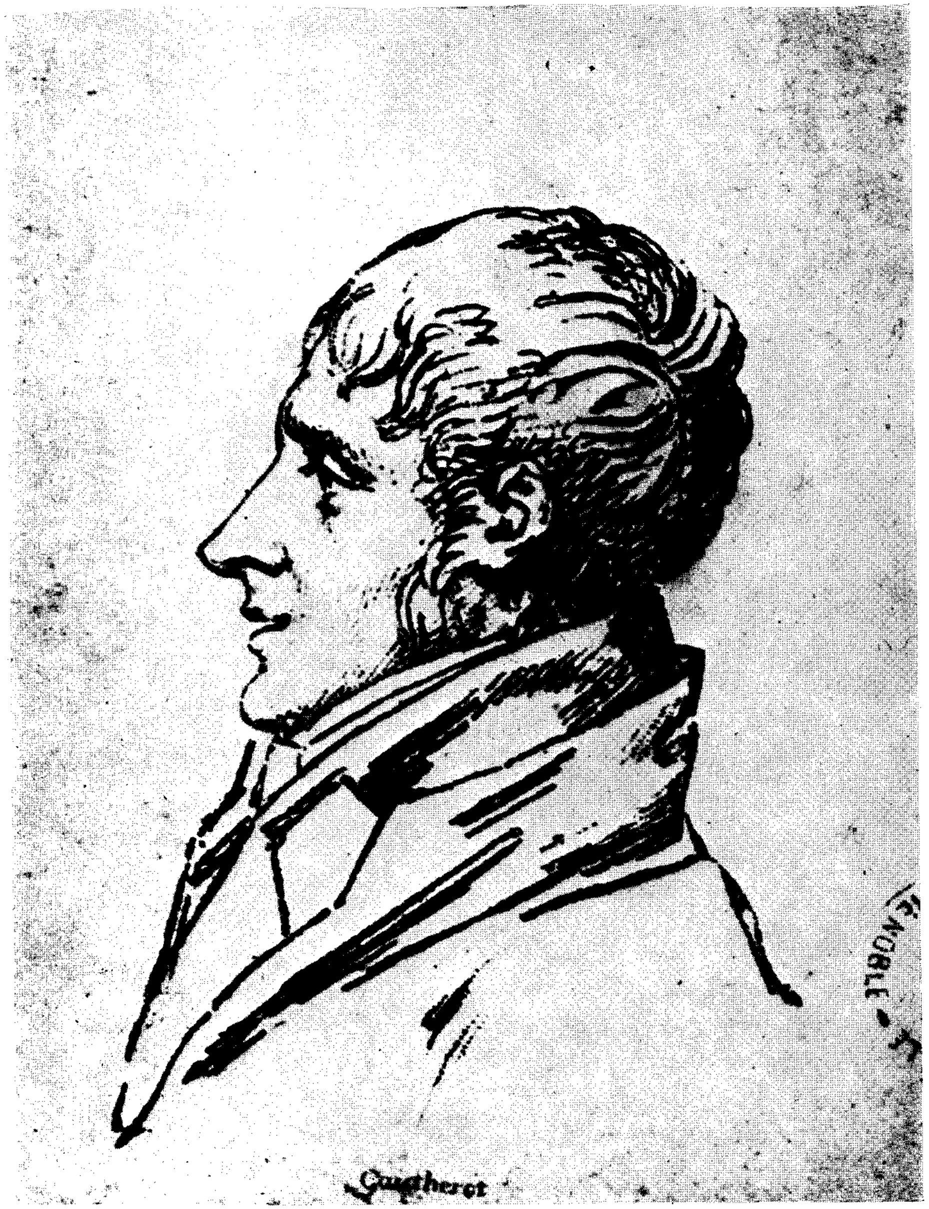
Joseph Fourier

The Man and the Physicist

John Herivel



Sketch of Joseph Fourier as a young man by his friend Claude Gautherot. An ardent Jacobin like his master David, Gautherot was one of a deputation of three who pleaded for Fourier's release from prison before the Committee of Public Safety at the height of the 'Great Terror' in Messidor Year II. (*Original in possession of the Municipal Library of Grenoble*)

JOSEPH FOURIER

THE MAN AND THE PHYSICIST

BY

JOHN HERIVEL

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FOR ELIZABETH
AND IN
MEMORY OF MY PARENTS

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MY PRIMARY debt is to certain institutions and individuals for the preservation of historical material. As regards persons, I am particularly aware of my debt to C. L. Bonard and his son Alphonse who out of feelings of respect and affection were responsible for preserving the magnificent set of early letters from Fourier to Bonard which make up the essential kernel of the biographical part of this book. As regards institutions, I am indebted to the Bibliothèque Nationale, the Archives Nationales, the archives of the Académie des Sciences, the Bibliothèque de l'Institut, the departmental archives of Isère, Rhône, and Yonne, and the municipal libraries of Auxerre, Grenoble, Lyons, Nantes, and Orleans. I am also indebted to many individuals in these institutions for the help they so willingly gave me to locate, copy, and, on occasion, photograph the various manuscripts in question. Special mention, however, must be made of Madame Gauja and her assistants in the archives of the Académie des Sciences, and of M. Hohl and his assistants in the departmental archives of Yonne.

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ABBREVIATIONS

Alm. Yon.	*Almanac de l'Yonne.*
AN	Archives Nationales, Paris.
Bib. Inst.	Bibliothèque de l'Institut de France.
Bib. Mun.	Bibliothèque Municipale.
BN	Bibliothèque Nationale, Paris.
Bio. Univ.	*Biographie Universelle.* With supplement 86 Vols, Paris, 1811–1862.
B.S.S.H.N.Y.	*Bulletin de la Société des Sciences Historiques et Naturelles de l'Yonne.*
Gde. Encycl.	*La grande encyclopédie.* Paris, 1885–1891.
Gd. Lar.	*Grand Larousse encyclopédique.* With supplement 11 Vols. Paris, 1960–1968.
Ind. Bio.	*Index Biographique des membres et correspondants de l'Académie des Sciences.* Paris, 1954.
J. Ecol. Poly.	*Journal de l'École Polytechnique.*
Proc. Verb.	*Procès verbaux des séances de l'Académie des Sciences, 1795–1835.* 10 vols. Hendaye, 1910–1922.

INTRODUCTION

Joseph Fourier, one of the most outstanding theoretical physicists France has produced, belonged to that very select band including Galileo, Newton, Maxwell, Planck, and Einstein, who by the originality, importance, and influence of their work effected revolutions in various branches of the subject. Great achievements in theoretical physics inevitably presuppose adequate mathematical powers. In Fourier's case these powers amounted to genius and his influence in both pure and applied mathematics was perhaps even greater than in the case of theoretical physics. Nevertheless his activities and achievements by no means ended with mathematics and theoretical physics. He led a most varied and interesting life. In the period 1793 to 1794 he played a leading part in the Revolution in his native town of Auxerre, was imprisoned twice and was fortunate to escape with his life. He was professor for a time at the École Polytechnique where he succeeded Lagrange, was a member of the Egyptian campaign and Permanent Secretary of the Institute of Cairo. In Egypt under successive commanders in chief, Bonaparte, Kléber, and Menou, he filled the most important civilian administrative positions. He made an outstandingly successful Prefect of Isère from 1802 to 1815, and was Prefect of the Rhône for a time following a dramatic encounter with Napoleon during the Hundred Days. Later he was elected a member of the Académie des Sciences, and as one of the two permanent secretaries of that body was at the centre of French scientific life from 1822 until his death in 1830. Fourier would therefore seem to present the ideal subject for that fully integrated biographico–scientific study of which historians of science sometimes dream. Unfortunately such a study is impossible in Fourier's case. In the first place, during the years between 1804 and 1811 which witnessed his most important and creative work in the subject, Fourier was a part-time physicist only. It was Fourier the prefect who supplied the money for Fourier the physicist to carry out his experiments and who somewhat miraculously found the time and intellectual energy to develop his theories on top of a host of important and onerous administrative duties. During all this time Fourier resided outside Paris which was then, as now, the almost exclusive centre of French scientific activity, and judged by the small number of surviving letters his relations with his colleagues in the metropolis were tenuous in the extreme.

What is more serious is that apart from one interesting but relatively unimportant paper published in 1798 there is absolutely no evidence of

Fourier having engaged in any serious theoretical physical researches before around 1804, that is for more than half of his total life span, and after he had already had interesting careers in local revolutionary politics and as the leading civilian administrator during the Egyptian campaign. Unless one were to devote a whole chapter to the 1798 paper—which would hardly be justified—the first serious technical discussion of Fourier the physicist would come roughly halfway through the account of his life. Moreover, as the greater part of all Fourier's work in theoretical physics was contained in his 1807 memoir, once the topic of Fourier the theoretical physicist had been broached it would be difficult to find any good reason to discontinue it until the greater part of the story had been told. The net outcome would be a biography in which roughly the first quarter up to Fourier's appointment as prefect of Isère was purely biographical, the next half purely scientific, and only the last quarter of mixed biographico-scientific content, with the scientific part of much less importance than in the preceding section. Faced with such an unconvincing and disconnected *pastiche* it seemed preferable to make a clean division into two parts, Part I on Fourier the man, and Part II on Fourier the physicist.

The biography of Fourier in Part I is the first to be based on all the currently available documentary and other evidence. It contains much new and hiterto unpublished material, especially on Fourier's part in the French Revolution, his defence of his 1807 memoir, and certain aspects of his life on his return to Paris in 1815. It would have been possible to produce a longer and more detailed biography of Fourier. The actual level of detail has been decided with an eye to maintaining a rough balance between the two parts of the present work. The resulting study of Fourier's life is certainly not to be regarded as definitive, though I hope that it will be accurate and reasonably complete, and that it will contribute ultimately to a definitive study in French by one of Fourier's own compatriots.

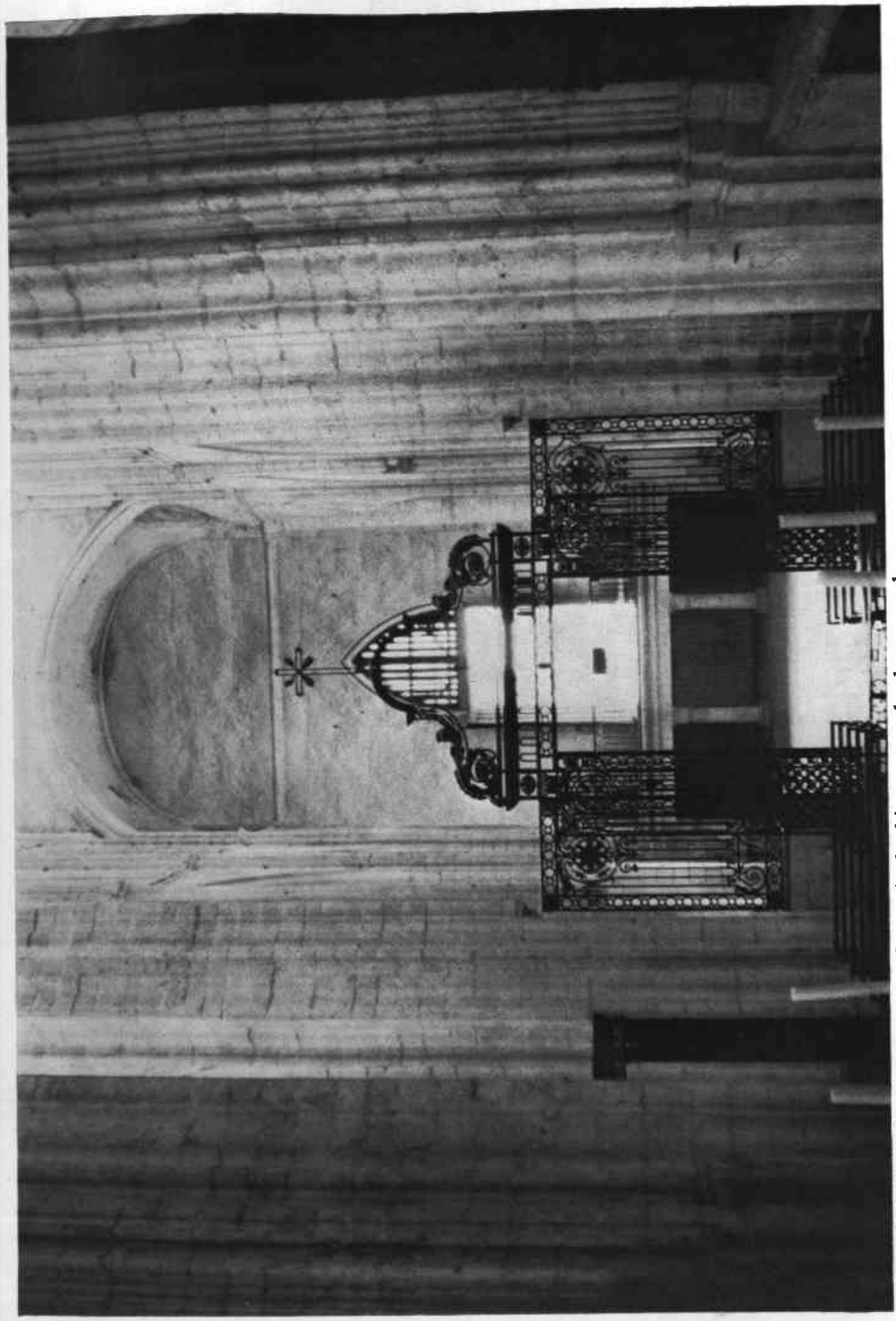
Unlike the case of Fourier's achievements *qua* theoretical physicist—which have been almost entirely neglected—his achievements and influence in pure mathematics have now been the subject of study by historians of mathematics for almost a century, and I am only concerned in Part II of the present work with Fourier the mathematician in so far as this is necessary for an understanding of Fourier the physicist. A topic-by-topic approach has been followed in Part II as being far superior to a chronological account as regards both presentation and insight afforded into the development of Fourier's thought. This separation into individual topics, though convenient, is nevertheless artificial, and to compensate for it a detailed historical survey is given in Chapter 7 covering the whole sweep of the development of Fourier's thought in the analytical theory of heat, a subject in which almost all his work in theoretical physics was concentrated.

While many of the facts presented in this chapter are not in themselves new, no complete chronological account of the whole of Fourier's work in the analytical theory of heat had been given before, and the present account contains new material based on documentary evidence which is here presented for the first time. The first part of Chapter 8 considers the formulation of the equations of motion for the various solids treated by Fourier, beginning with the crucially important case of the thin bar. This part of Chapter 8 is largely novel, whereas the second part, which deals with his solutions to these equations, a topic to which much attention has already been devoted, is given a much more summary treatment. Chapter 9 contains new insight into the gradual perfection of Fourier's treatment of the rate of flux of heat problem. Chapter 10 is devoted to a number of miscellaneous, unrelated topics which are simultaneously too important to be omitted and yet in no case necessitate a sufficiently extensive treatment to require separate chapters to themselves.

The division of this book into two parts should not be taken to imply that I believe that Fourier's rich and varied experience of life was entirely divorced from his work in theoretical physics, and in the last part of the Epilogue, where a summing up is made of Fourier's career both as a man and a savant, consideration is given to the question of possible interactions between Fourier the man and Fourier the physicist.

It proved impossible to find an entirely satisfactory consistent policy for the location of the rather large number of biographical notes. The solution of putting these notes together in a separate appendix was rejected on the grounds that they would then tend to be ignored both in the text and in the letters. The alternative of giving a biographical note at the first occurrence of the person concerned whether in the text or in the letters would have involved many tiresome backward references in the letters which in any case had to be given priority over the text on scholarly grounds. It seemed best therefore to give biographical notes to all persons appearing in the letters as part of the notes to the letters themselves, and to provide appropriate forward references to any appearances of the same persons in the text. The lengths of these biographical notes were determined largely by the importance of the persons concerned for the present work, as opposed to their own intrinsic importance as historical figures. Thus Bonard, a mathematician of no importance but the teacher and close friend of Fourier, receives considerable space, whereas François Arago, Fourier's successor as permanent secretary at the *Académie des Sciences*, and one of the foremost French physicists of his day, but neither a friend nor an enemy of Fourier, is dismissed in a few lines, as are Ampère and Fresnel, and for the same reasons. On the other hand, Laplace and Lagrange, important both for themselves and for Fourier, receive lengthy notices. At the other extreme certain figures such as Robespierre and Danton are too well known to require biographical notes, and Lazare Carnot only qualifies because of his eminence as a scientist.

Belfast J.H.
September 1973



1. The interior of the Abbey St. Germain looking towards the west door

PART I

FOURIER THE MAN

I

EARLY LIFE

1. Auxerre

Joseph Fourier, by turns novice, abbé, Jacobin, secretary to the Institute of Cairo, prefect of Isère under Napoleon and the First Restoration, and of the Rhône for a time during the Hundred Days, permanent secretary of the Académie des Sciences, and remembered today as the author of the epoch-making Analytical Theory of Heat, was born on 21 March 1768 in the ancient town of Auxerre. His father Joseph Fourier, a master tailor of Auxerre, had been born in the small town of Raville in Lorraine where his parents Simon and Anne Marie Fourier had been shopkeepers. Nothing is known of the year in which Joseph left Lorraine, his reasons for so doing, or why he ended his westward journey in Auxerre in preference to other nearby towns such as Sens, Troyes, or Tonnerre. If he shared his famous son's love of elegance and beauty he could simply have been attracted by the town itself, magnificently situated on its height dominating the river Yonne, with its many fine buildings including the ancient clock tower, the Abbey St. Germain, and the Cathedral St. Etienne, all happily still standing today. Or he could equally have been attracted by the people of Auxerre themselves, by the striking beauty of its womenfolk and the sound common sense, independence, and civic pride of its male citizens. For although Auxerre had endured its fair share of the ills to which European towns in general, and French towns in particular, were in the past heir—barbarian invasions, plague and pestilence, occupation (though not destruction) by English forces for a time during the Hundred Years War, and the attentions of Huguenot iconoclasts during the wars of religion in the sixteenth century—it had escaped other major calamities including destruction by the Normans,[1] and by 1751 was as prosperous and independent a town as the general situation and government of France at that time would allow. Joseph Fourier might finally, and perhaps most probably, have been attracted to Auxerre by the ecclesiastical standing of a town which had had its own bishop since Gallo-Roman times and which besides a great number of parish churches, some of them very large and fine, also boasted the magnificent gothic Cathedral St. Etienne, and the even more ancient and more famous Abbey St. Germain, the special pride of the town since its foundation by St. Germain himself in the fifth century A.D. Such a rich and powerful ecclesiastical establishment would necessarily afford tailors much lucrative trade, in which Joseph Fourier might have expected some special consideration in pious memory of his paternal great uncle, the Blessed Pierre Fourier,[2] one of the leading figures of the Counter-Reformation in Lorraine in the sixteenth and early seventeenth centuries. In any event, Joseph Fourier's famous son Jean Joseph Fourier does seem to have been treated with special consideration by the ecclesiastical authorities in Auxerre, though this could simply have been due to his own intellectual brilliance rather than the saintly connection on his father's side, a connection, however, of which Fourier himself seems to have been very proud in later life.

By his first wife Marie Colombat, whom he married in Auxerre in 1751, Joseph Fourier had three children. On her death aged thirty-six in 1757 he married, secondly, Edmie Germaine LeBegue by whom he had twelve further children, the first born in 1759, the last in 1774. The ninth of these children, and the subject of the present study, was born on 21 March 1768 and christened Jean Joseph[3] the same day. Edmie Fourier died on 26 October 1777 at the age of forty-two. At the time of her death she resided in the Place de la Hôtel de Ville, her husband and she having moved there from their previous residence in the rue Notre Dame (now rue Fourier) where Jean Joseph Fourier was born. Three days later, distraught by his wife's death, Joseph Fourier abandoned his two youngest children, aged three and four years, to the Foundling Hospital (Hôtel de Dieu). Early the next year (1778) he followed his wife to the grave. Jean Joseph was therefore left an orphan a little before his tenth birthday.

Fortunately for Fourier, his parents' deaths seem to have caused little interference with his education. He received his first lessons in Latin and French in a small preparatory school kept by Joseph Pallais,[4] organist and master of music at the Cathedral St. Etienne. Later, attracted by his quick mind and winning ways, a number of local worthies[5] made it possible for him to proceed from Pallais' school to the local École Royale Militaire.[6]

The École Royale Militaire of Auxerre was one of eleven such provincial schools which had been given this special designation in 1776 on being required to take each some fifty to sixty poor pupils of noble birth destined for the army.[7] Each school was placed under the direction of a religious teaching order: those at Sorèze, Tiron, Rebais, Beaumont-en-Auge, Pontlevoy, and Auxerre were under the Benedictine congregation of St. Maur,[8] those at Vendome, Effiat, and Tournon were directed by the Oratorians, and those at Brienne—Napoleon's college—and Pont à Mousson by the Minimes and the Chanoines of St. Sauveur respectively. The reputations of the various Écoles Royales Militaires naturally varied from one school to another depending largely on their standings prior to their change in status. Thus among the Benedictine schools, that at Sorèze[9] was by far the best known with a long-established reputation for progressive methods of teaching and emphasis on science and mathematics, and of the remaining schools that at Pont à Mousson was perhaps the most highly regarded. However, a certain measure of uniformity was ensured by regular visitations from a panel of inspectors—set up by the Minister of War in 1776—which included the *Chevaliers* Keralio[10] and Charbonnet,[11] and the *académiciens* Legendre[12] and Bailly.[13] The presence of the last two indicated the special importance attached to the teaching of science and mathematics in the Écoles Militaires by reason of the requirements of those pupils who entered the specialist corps of artillery and engineers. The use of certain textbooks, especially those of Bézout[14] and Bossut[15] in mathematics, also helped to maintain uniform standards and to improve the levels of instruction by enabling more time to be devoted to teaching as opposed to lecturing.[16]

The declaration converting the college at Auxerre into an École Royale Militaire was dated 31 October 1776, though it was not registered by the *Parlement* of Paris till 10 June 1777,[17] and the college—which had been closed on 1 November 1776—was reopened under its new title in October of the same year. Under the Benedictines it soon regained a great measure of its previous prosperity though the total number of pupils never exceeded 120 as opposed to the maximum of around 200 in the earlier college. Fourier entered in 1780[18] and quickly distinguished himself by the happy ease and quickness of his mind, being said always to have been at the head of his class, so that he was soon received free as an internal student, the Benedictines no doubt seeing in him a possible future recruit to their teaching order. At first he is said to have shone most in literary studies, and Challe relates how in his own school days at the College of Auxerre he heard of Fourier's marvellous facility for composing verses, especially those of a light and playful nature. At about the age of thirteen, however, a growing passion for mathematics began to dominate all other interests. According to both Cousin and Mauger he was at this time in the habit of collecting candle ends by day in order to steal down to the classroom at night and devote long hours to the study of mathematics in some sort of store room or large 'cupboard'. One night the then deputy principal, Dom Laporte, while making the rounds of the school saw a light through the keyhole of the 'cupboard'. Fearing a fire he rushed in only to discover the young Fourier absorbed in mathematical problems.[19] History does not relate if Fourier was thereafter prevented from burning his candles at both ends.

In this way by the early age of fourteen he is said to have completed his rhetoric and mathematics and to have become intimately familiar with the six volumes of Bézout's course of mathematics. Mauger's account here is confirmed by the records,[20] for at the prize giving on 29 August 1782 Fourier divided the *prix d'excellence* in Rhetoric and obtained a *prix de composition* in mathematics. He also obtained first prize for singing, while the next year he obtained first prize for Bossut's Mechanics. Thereafter there is no trace of Fourier in the prize lists. It is known[21] that he had a prolonged illness from December 1784 to November 1785, the result, perhaps, of his excessive application to study, and possibly the beginning of a tendency towards insomnia, dyspepsia, and asthma from which he suffered much in later years.

According to Mauger, Fourier's success had now inspired a lively interest among the notabilities in Auxerre, with the Benedictines and the bishop, de Cicé,[22] disputing the honour of being his patron. Eventually he was placed in the Collège Montaigu at Paris by the beneficence and under the protection of the prelate. There he repeated with distinction his rhetoric course and took his philosophy, completing his studies at the early age of seventeen. At this time, or possibly at the end of his studies at the École Militaire, and before the long illness referred to above, he wished to enter the artillery or the engineers, his application to the Minister of War having the support of the then inspectors of the school including the mathematician Legendre. Fourier's application, however, met with the crushing reply that as he was not noble he could not enter the artillery (or the engineers) 'even if he were a second Newton'![23] In any event, on returning to Auxerre he at first assisted in the teaching of mathematics. He then decided to enter the Church, and in 1787 proceeded to the Benedictine abbey of St. Benoit-sur-Loire to prepare for his vows while acting as professor of mathematics to the other novices.

2. St. Benoit-sur-Loire

In the course of the second half of the eighteenth century the regular (monastic) orders in France found themselves in an increasingly precarious position. Combining great wealth in land, buildings, and treasure with steadily dwindling numbers of inmates, they provided a standing temptation to a government which was continually poised on the verge of bankruptcy. This temptation became irresistible once the Revolution had broken out, though during the immediately preceding decades many monasteries had already been closed down as redundant. St. Benoit-sur-Loire had been spared, not, it may be surmised, because of its architectural splendours—the famous basilica built between 1067 and 1281 is today one of the finest surviving examples of French Romanesque with little or no regional influence. The reason was more probably the continued contribution of the congregation of St. Maur to teaching and learning, or the peculiar sacredness of an Abbey which had been one of the foremost shrines of Christendom ever since the body and relics of St. Benedict had been transferred there from Monte Cassino in the seventh century, or even possibly the long connection of the Abbey with the Crown in the Middle Ages—hence the prefix 'royal'—when it had often acted as host to the Kings of France at a time when royal chateaux such as those of Blois and Fountainbleau still remained to be built.

Nothing would be known of Fourier's life at St. Benoit from 1787–9 were it not for three letters written by him from there to his friend and former Mathematics Professor at Auxerre, Bonard.[24] The period from the beginning of the year 1787 when he entered St. Benoit and the first extant letter to Bonard in May of the following year was hardly conducive to meditation, teaching and research, even behind the high walls of the Abbey St. Benoit. All France, not least Fourier who was invariably well-informed of events in spite of an assumed indifference to external affairs, watched with mingled hope and fear the dramatic incidents of the so-called 'Aristocratic Revolution' in which much of the remaining authority of the Crown was destroyed by the refusal of the notables to grant those reasonable financial and fiduciary reforms, which alone could have prevented the final bankruptcy of the King and the consequent convocation of the States General. February 1787 saw the meeting of Calonne's notables, April the replacement of Calonne by Brienne, August the revolt of the *Parlement* and its exile to Troyes, September its recall, November the dramatic imposition of taxes by the King and the exile of the Duke of Orléans answered by the vote of *Parlement* against *lettres de cachet* in January, and its declaration of fundamental laws of the realm to which the inevitable reaction was the armed coup of 5–6 May. The transfer of many of the powers of *Parlement* by the edict of 8 May was then the signal for riots in Paris and elsewhere.

It was against this increasingly menacing situation that Fourier wrote to Bonard on 22 May.[25] Ever an erratic correspondent, Fourier opens with an elaborate apology for his dilatoriness:

> On occasion others have graciously forgiven me too long a silence; I hope for the same indulgence from you. This accursed habit follows me everywhere, call it what you will; the fact remains that I like and infinitely esteem people, and yet do not write to them. However, I only wrong myself, it is one pleasure the less and you know that I have said goodbye to pleasures for the moment.

Fourier continues with an account of his life at St. Benoit. The picture he paints is not a very happy one. He is evidently a trifle uncertain if he was not after all mistaken in entering St. Benoit 'against the advice of many persons'. Having wished to devote himself to 'study and religion' he finds himself immersed in the 'petty concerns' of studies, classes, arithmetic lessons in which last he will soon be at 'fractions' ![26] He modestly confesses himself uncertain whether he will be able to live up to the high reputation with which he entered the Abbey. He admits that one solid advantage compared with Auxerre is the regularity of his life at St. Benoit including a nightly eight hours' sleep. But this, alas, leaves him 'no time for living', especially as his nights are not illuminated by Cartesian type dreams. Above all he longs to hear news of his paper on algebra which Bonard had evidently sent for an opinion to various Parisian mathematicians of the day including a certain Montucla.[27] He would, he says, be 'enchanted' to know the opinion of these mathematicians. He chats of various mathematical matters including an elegant solution of some little problem in analysis provided by Bonard whose memoir on a 'curve with double curvature' he promises to return soon, and he challenges Bonard to find a way of arranging 17 lines in a plane so as to give 101 points of intersection. As well as news of his precious paper he also desires to be sent 'mathematical, physical and astronomical news'. Has the Marquis de Condorcet[28] published what he is said to have written on modern calculus? Is it true that M. de la Grange [Lagrange] and other *académiciens* employ eight months of the year in visiting the Écoles Militaires?[29] He rightly cannot persuade himself to believe such a tall story. As to political news, he feigns his usual indifference: 'those who fight each other tear themselves to pieces'. As an earnest of this indifference he has surrendered his subscription to the Journal of Geneva:[30] 'the world and I' he declares somewhat pompously 'will have to grow several years older without knowing each other'—a rash prediction to hazard in the France of May 1788, and in Fourier's case, as it turned out, a singularly inaccurate one. At this point he concludes with a pious prayer for the simultaneous epistolatory reformation of Bonard and himself:

> I end a letter which is already too long, you could revenge yourself by the length of yours; there would also be a way of correcting my negligence, namely by setting me an example of the opposite quality. I recommend you to try this method, you will oblige him who with sentiments of esteem and attachment has the honour to be
>
> Your very humble and obedient servant,
> Fourier.

Between this and Fourier's next extant letter, the descent to the Revolution had gathered irresistible force. The disturbances of May 1788 had made way for insurrection in June, and opposition to proposed reforms so widespread and formidable that Brienne had first retreated and then retired, Necker had been recalled, *Parlement* reinstated, and the King's credibility having been destroyed, battle was joined between the notables and the third estate. Chaos was everywhere, in Brittany there was civil war, and the whole country was full of a flood of conflicting pamphlets. Amid all this turmoil the letters of convocation of the States General went out on 24 January, and throughout the land the three orders met to draw up their lists of grievances and elect representatives for the States. It was against this background—when the father Prior, Dom Charpentier, was absent from St. Benoit to take part in the preliminary assembly of clergy at Orléans,[31] when, as Fourier so vividly puts it: 'Everything resounds with the news of the day'—that he wrote to Bonard on 22 March 1789.[32]

Once again Fourier affects a tone of lofty, even callous indifference to events outside the Abbey. It is not to be expected that he, Fourier, will discuss such matters with Bonard any more than the accidents caused by a serious flooding of the Loire, which 'frightened many, and did harm to some, but to me neither one nor the other'. Judging by this attitude it might be surmised he has been reading the works of the Stoic philosophers. In fact, apart from a 'miserable copy of Montaigne' there is evidently an almost total lack of books in the Abbey:

> Is it not to be condemned to ignorance not to be able to read any other books but one's own? It is a privation not to be consoled by all philosophy. I have no books to read but a miserable copy of Montaigne lacking certain pages which I am reduced to guess at; I busy myself a little with Greek; you can well believe that it is for reading Euclid and Diophantus rather than Pindar and Demosthenes.

As to his health, it has not been too good and for the last five months he has constantly had a 'weak stomach and difficulty in sleeping'. This sets him thinking that he has bought very dearly some 'rather fragile knowledge' not easily marketable. As for his mathematical studies, they, too, evidently hang fire:

> Alone and without help one can meditate but one cannot make discoveries; often by flying the world one becomes better, but not wiser; the heart gains and the mind loses.

Not that he has lost faith in the paper on algebra sent to Paris. On the contrary he is confident that his methods are the 'true methods' and the Italian ones 'absurd and opposed to all that is most certain in analysis'. So that it is 'impossible that a genuine mathematician should reject such powerful evidence'. In spite of all this no answer has yet come from Montucla whom Fourier suspects of having lost interest in 'learned analysis'.

Having referred to an incorrect enunciation of a theorem in another memoir on numerical equations—to be presented in person by Fourier to the Académie des Sciences the following November—and having somewhat pompously cautioned Bonard that 'one must not replace errors by errors' Fourier concludes:

> Forgive me the trouble this letter has caused you, all the disorder and bitterness you will find in it. If you only knew the effect of a passion for the truth when it is constrained to be sterile, and all the treachery which ungrateful truth reserves for her devotees. But if it is hard to suffer her caprices, it is very pleasant to complain of them. And who would grudge me this pleasure? For me pleasures are so rare.

From this passage it is evident that in spite of the lack of books at St. Benoit, Fourier had somehow managed to come by the works of Jean-Jacques Rousseau, provided, of course, he had not already read them at Auxerre. But if one dismisses the tone of this passage as being due more to the prevalent climate of opinion than to Fourier himself, it is impossible to doubt the genuine anguish expressed in the postscript to the letter:

> Yesterday was my 21st birthday, at that age Newton and Pascal had [already] acquired many claims to immortality.

One further letter[33] to Bonard from St. Benoit has survived. Taken up entirely with the lack of news about the paper on algebra supposedly communicated to Paris by Bonard and the latter's failure to reply to his last letter, it provides a good example of Fourier's ability to bring pressure to bear on recalcitrant correspondents:

> On this occasion I shall no longer complain of your silence; I must declare myself since you have done so. This correspondence with which you yourself had charmed me was no more than a pleasing chimera; but what is there that cannot be consoled by time and reason?...
>
> ... If you were to put between your reply and my letter too long an interval I might perhaps lose the opportunity which is going to present itself to send what I have written to Paris.

Judging by the lack of any reference to the great events which were sweeping away the old order of things in France, Fourier would seem to have been somewhat indifferent to the Revolution. But if this was really the case—which may be doubted—he was unable long to escape its consequences. On 28 October the Constituent Assembly took the first step towards the abolition of monastic orders by a decree forbidding the taking of any further religious vows. This was followed on 2 November by a decree putting the property of the regular congregations at the disposal of the State. Finally, on 13 February 1790 the suppression of all religious orders was decreed in principle with the striking exception of Fourier's own congregation of St. Maur which was deemed to have deserved well of the State by its virtues and love of letters. Sometime earlier, however, Fourier had said farewell to St. Benoit and returned to Auxerre to take up a position as assistant to Bonard in the teaching of mathematics at the École Royale Militaire.

3. Return to Auxerre

Accounts differ as to when Fourier left St. Benoit. According to Cousin[34] it was just before the outbreak of the Revolution, whereupon he is said to have discarded his Benedictine habit without regret, having in any case never taken his vows. However, from the letter of September 1789 to Bonard it appears that Fourier was at that time still at St. Benoit. Challe[35] is more circumstantial. According to him Fourier was preparing to take his vows in Auxerre on 5 November 1789, when news had reached the town the previous day of a provisional order[36] of the Constituent Assembly prohibiting the taking of any further such vows. Fourier was thus unable to take his vows at that time, and never did so subsequently, the Assembly later confirming the provisional order, making it definitive and final.[37] Mauger[38] has still another version, according to which the Prior of St. Benoit, foreseeing the imminent suppression of all religious orders, advised Fourier to take his vows since he would then be entitled to a pension if the orders were suppressed! Fourier's refusal then provided the first recorded example of his disinterestedness.

There are, finally, two hard pieces of information about Fourier's whereabouts towards the end of 1789 and the beginning of 1790: in the first place he is known[39] to have been in Paris on 9 December 1789 to read a paper on algebraic equations to the Académie Royale des Sciences, presumably after he had left St. Benoit. In the second place there is the account of Fourier himself in a declaration of 30 April 1790:

> J. B. J. Fourier aged 22 years declares that having completed his noviciate at St. Benoit-sur-Loire it was in respect of the decree of the Assembly National that he did not pronounce his vows, but that called to Auxerre to profess rhetoric and mathematics he has the intention of remaining in the congregation of St. Maur.[40]

This declaration of 30 April 1790 was on the occasion of a visitation the same day to the Abbey St. Germain by two representatives of the municipality of Auxerre sent to enquire the intentions of the inmates in the light of the decree of 13 February relating to the suppression of religious orders. Of the remaining eleven members of the ancient Abbey, nine, including 'the novice Fourier', declared their intention of observing their vows in the Congregation of St. Maur. The Benedictines thus continued to direct the college of Auxerre which now had the double title Collège Nationale and École Royal Militaire.

Later the same year Fourier appears as the Abbé Fourier in charge of the third class at the college on a list[41] of teachers submitted to the municipality by the Principal, Dom Rosman.[42] In addition to the teaching of rhetoric and mathematics referred to in the declaration of 20 April 1790, Fourier is said later to have filled the chairs of history and philosophy,[43] and to have given special courses in astronomy for advanced pupils.[44] He was active, too, in the town where he was the first president of a 'Society of Emulation'.[45]

It is uncertain[46] whether Fourier continued to teach in the college at Auxerre during the whole period from April 1790 till his appointment or reappointment in June 1793, following the dismissal of all the so-called professor-priests including the Principal, Dom Rosman. In any case, after the declaration of 30 April 1790 life seems to have continued at the college much as before apart from a new plan of studies[47]—said to have been drawn up by Fourier himself—submitted to the municipality by Dom Rosman, the principal, sometime in the year 1790. In the early part of 1791 the Abbey was in danger of being sold as a result of the decree placing all ecclesiastical property at the disposal of the State. To avert this calamity Dom Rosman petitioned the local authorities on 20 March 1791 for permission to transfer the college and École Militaire to the Abbey, to which a number of pupils had already been transferred in 1788 when the buildings of the old Collège d'Amyot had become inadequate. The petition was granted, and on 31 July 1791 the commission of dispossession of ecclesiastical properties allowed the building of the Abbey to be turned over to the use of the pupils, the church being preserved as a public oratory and a chapel of the college.

In the same year there was a visitation of the college by a commission of the municipality, possibly in connection with Dom Rosman's petition. Once again, as on the occasion of an earlier visitation in 1783, the financial affairs of the college were found to be in a chaotic state:

> No order in the accounts of which the greater part are neither made up nor signed. Gaps in almost all matters relating to accounts. Loose leafs for the receipt of pensions in a state of disorder. In short an almost inextricable chaos.[48]

But a wise municipality turned a blind eye to such unimportant failings, and the college continued its pedagogically useful and successful life.

A commissioner[49] of the local directory who visited the college on the morning of 30 October 1792 reported favourably on its physical state, the

health of the pupils, and the education received by them. Everything was clean and proper, in an excellent state of organization, the air salubrious, the children well-fed and strong and healthy for the most part. In the classes there was a free, progressive, and liberal atmosphere, the old written exercises having largely been replaced by discussion. The standard of teaching was particularly striking in mathematics and physics, and the report even deplored the tendency to drive out Latin and other classical studies to make way for the mathematics so much in demand at the time by the parents of pupils. Latin, it was pointed out, was important for teaching precision of thought and an understanding of human nature, and it would be a pity if it were to be reduced too much.

Reading the commissioner's report on his visit to the school on 30 October 1792 and his apparent unconcern at the fact that the majority of the teaching staff at the school were in holy orders, albeit of the juring variety, it is difficult to believe that some two months before hundreds of priests had been massacred in the prisons of Paris. Not that Auxerre had escaped entirely unscathed from the shock-wave emanating from Paris after the fall of the Throne on 10 August. On the nineteenth of that month there had been a riot in the town in the course of which two innocent men were murdered by a mob in the Hôtel de Ville.[50] But this was fortunately an isolated incident. These seem to have been the only two violent deaths in Auxerre directly attributable to the Revolution, and whatever the reason, good fortune, lack of involvement in the Federalist revolt in 1793, or the wise moderation of Nicolas Maure,[51] deputy for the district of Auxerre at the Convention, the town was never disgraced by the guillotine, nor were any of its citizens brought before the Revolutionary Tribunal.

However, if there was little or no bloodletting in Auxerre during the Revolution this is not to say that the town was in any way isolated from the events in the rest of the country, something which was in any case only possible, if at all, for a few odd individuals or families in a few corners of the country. In fact the local Society of the Friends of the Republic (later the Popular or Patriotic Society) was one of the best known and most active and most *militant* provincial clubs in the country. It appears[52] that this society had been founded by that curious and enigmatic figure, Michel Lepelletier,[53] one of the so-called martyrs of the Revolution. When Lepelletier arrived in Auxerre in the autumn of 1791 with the painter Claude Gautherot[54] in tow as his secretary and general factotum, he found there a Society of the Friends of the Constitution which seems to have been established towards the end of 1790, and which continued in existence under the same name in 1791 and 1792. The democratic ideas of Lepelletier had need of a more efficacious, wider and less *elevated* base for their propagation than that provided by the well-to-do members of the essentially bourgeois Society of the Friends of the Constitution. As a result of the fatal self-denying ordinance of the preceding Constituent Assembly, Lepelletier was not eligible for election to its successor the Legislative Assembly, and he wished instead to obtain for himself a high post in the departmental administration to which he already had an aristocratic claim through his vast possessions in St. Fargeau, one of the regions of the department of Yonne. In this he was eminently successful, being elected president of the departmental administration, a position which he then continued to occupy till his election to the Convention in September 1792. The wider base sought by Lepelletier and Gautherot could only be provided with the support of 'little people' including artisans, shopkeepers, workmen, and small-salaried people who lacked the necessary financial means and leisure to belong to the Society of the Friends of the Constitution. There resulted the foundation of a new society, the Popular or Patriotic Society of Auxerre, or the Society of Friends of the Republic—the title was somewhat flexible —of which Gautherot continued to be the leading light until 9 Thermidor when he discreetly slipped away to Paris never to return to Auxerre again. The Popular Society of Auxerre was dynamic, definitely *sans-culotte* and even verging towards *Hébertism*, for if it could not be regarded as an organ of Hébert in the strict sense, at least it was enthusiastic for the sort of political, social, and economic ideas found in Hébert's infamous magazine the *Père Duchesne*. Thus when the question of the King's trial began to agitate the country the Society at Auxerre sent a passionately worded address[55] to the Convention demanding the trial of Louis:

> Legislators.
>
> We are disturbed to see that having received the express desire of the people united in all the debates of the Republic that Louis should be tried, the National convention has decreed nothing in regard to the matter. Deputies have recognized the justice of this demand, and have promised to carry it out. Why have they not done so? This is what we ask you to explain.
>
> On the day of 10 August the will of the people expressed itself in this unanimous cry: that Louis should pay the penalty of his heinous crime. Your decree on the Republic implies a second one which demands the beginning of the trial of this traitor . . .

Gautherot was one of the more prominent signatories to this address. There was no trace, however, of the signature of either Bonard or Fourier. In Bonard's case the absence of his signature was possibly due either to moderation or prudence, since he was signatory to another less inflammatory address[56] of the Society to the Convention a few days later on 15 October. As for Fourier, it seems that his entry onto the local revolutionary scene did not occur until February 1793.

Notes

1. Although the Normans penetrated the Yonne as far as Auxerre in 887, 889, and 911 they never succeeded in capturing the town. But they laid waste the surrounding countryside and pillaged the abbey of St. Marien.
2. Pierre Fourier (1565–1640). Known as the good father of Mattaincourt, he was born at Mirecourt, in Lorraine, and educated at the College of Pont à Mousson. He became Canon in the Abbey of Chaumousey, and was ordained in 1589 but was later ordered to return to Pont à Mousson to become learned in patristic theology. Like his great-grand-nephew he had an exceptional memory and knew the *summa* of St. Thomas Aquinas by heart. In 1597 he was appointed parish priest of the 'corrupt' parish of Mattaincourt where he soon restored morals and religion. He also looked after the temporal interests of his flock founding a kind of mutual-help bank. In 1598 he founded the congregation of Notre Dame for teaching poor girls, and in 1621 he undertook the reformation of the regular canons in Lorraine which led to the formation in 1629 of the Congregation of Our Saviour. On account of his attachment to the House of Lorraine he was driven into exile at Gray where he died in 1640. In 1730 the Pope Benedict XIII published a decree for his beatification, and in 1897 he was canonized by Pope Leo XIII. (*Cath. Encycl.*: these are lives of Pierre Fourier by Bedel, Derréal, and Vuillemin).
3. In the baptismal records of the Parish of St. Regnobert, Auxerre, Fourier is entered as Jean Joseph. When Champollion-Figeac first knew him in Grenoble he employed the first names Jean Baptiste Joseph. Later he employed Joseph only.
4. Born around 1706, Joseph Pallais was appointed organist of the cathedral St. Etienne in 1734. He was still in service at the time of the profanation of the cathedral in 1790. Pallais was a friend of Jean-Jacques Rousseau to whom he had taught the first elements of music, and whom he is supposed to have hidden in Auxerre when Rousseau was fleeing from Montmorency. His contribution to Rousseau's musical education prompted the directory of the department to award him a retirement pension of 800 livres per annum, a sum far in excess of his salary as an organist. Pallais was the author of *Les Principes d'accompagnement pour l'organe et le claireau* (Gardien; Mauger; Quantin.).
5. According to Mauger (p. 1) it was a certain Madame Mouton and several other generous persons in Auxerre who enabled Fourier to continue at Pallais's school when he had become an orphan and then to enter the École Royale Militaire as an external pupil. Cousin (p. 2) refers to a 'good lady',—evidently the Madame Mouton of Mauger's account—who recommended him to the Bishop of Auxerre (De Cicé) who then had him placed at the École Royale Militaire.
6. The educational tradition in Auxerre was a very ancient and honourable one: it extended back in unbroken succession as far as the fifth century A.D., and included a period in the ninth and tenth centuries when Auxerre was the foremost centre of learning in France with outstanding teachers such as Héribald, Hérac, and Rémie, the last named being the renovator of the school of Chartres. After their period of brilliance in the ninth and tenth centuries the schools of Auxerre suffered a steady decline as the centre of French learning shifted back first to Chartres, then to Paris, and by the middle of the sixteenth century little remained of their former glory beyond the title *Grandes Écoles* of the local college where the humanities were taught by a principal and four professors. In

the second half of the century a new college was built through the munificence of Jacques Amyot (1513–93) Bishop of Auxerre, one of the most brilliant scholars of the French Renaissance whose translation of Plutarch played an important role in the creation of written French. Amyot had originally intended his college to be under the Jesuits whose education was at that time increasingly in demand by the French middle-classes. But the formation of the League under the instigation of the Jesuits against the King Henry III whom Amyot had taught and later served as grand almoner, and whom he greatly loved, changed his attitude to the Jesuits and their direction of his school. When Amyot died in 1593 after cruel persecutions and almost a prisoner in his own see—for Auxerre had sided with the League against the King—his kinsmen tried to let the new building against the wishes of the municipality. The ensuing law suit dragged on for many years until it was ultimately settled by the *Parlement* of Paris in favour of the town, and in 1622 the Jesuits at last took over control of Amyot's college. To the original teaching of grammar and the humanities philosophy was added in 1651, but the school never seems to have been very prosperous under the Jesuits and at the time of their expulsion from France in 1762 it had no more than fifty-five pupils.

Following the expulsion of the Jesuits the college at Auxerre was taken over by a mixed band of teachers, lay and clerical, under whose direction it had soon attained a state of prosperity far beyond anything enjoyed previously, the number of pupils having risen to 200 by 1765. The college continued to flourish until 1772 when it underwent a sudden and catastrophic change of fortune following the victory of the pro-Jesuit party in Auxerre over the opposing Jansenist party which had been particularly strong in Auxerre as a result of the long reign of the universally admired and respected pro-Jansenist de Caylus, Bishop of Auxerre from 1704 to 1754. Attempts by the strongly pro-Jesuit Bishop de Cicé to have all remaining pro-Jansenist professors at the college dismissed and even sent to the galleys were ultimately unsuccessful. But the disturbance in the life of the college was very great and it never entirely recovered its earlier prosperity under the Benedictines, the total number of pupils never exceeding 120 as opposed to a maximum of around 200 in the earlier college (*Gde. Encycl.*; Challe (1); Moiset).

7. This move had followed the closing by the Minister of War, the Count of St. Germain, of the École Royale Militaire in Paris. Opened in 1753 to provide education for up to 500 pupils of noble birth with insufficient means to obtain their education elsewhere, it had been closed by St. Germain because of the small number of its pupils who had entered the artillery or engineers in spite of a large outpouring of funds, and also because it had never been possible to take more than about half of the 500 pupils originally envisaged, once again on the score of expense. St. Germain evidently hoped that the new system of Écoles Royales Militaires scattered over the country would provide a cheaper method of catering for a larger number of pupils. He was concerned too with the somewhat exclusive attitudes engendered by the school in Paris with its pupils made up entirely of the sons of the nobility. He hoped that in the new schools these pupils would learn to mix with others of less distinguished pedigree. Evidently the spirit of the Enlightenment had even penetrated the corridors of the Ministry of War. St. Germain seems to have been genuinely interested in the educational, physical, and moral well-being of the military pupils. Glaring gaps in the most elementary aspects of education had shown up in the French officer classes during the Seven Years War. These had to be remedied. Special attention was to be paid to those subjects which would later be important to officers, especially in the artillery and the engineers. Room had therefore to be found for more mathematics, if necessary at the expense of Latin. But St. Germain's plan sought to avoid falling into the opposite extreme of excessive and self-defeating application to studies. It was essential to pay attention to the physical well-being of the pupils. Suitable sports were to be encouraged, and excessively long periods of enforced stillness in class were to be forbidden or at least reduced. No aspect of the pupils' well-being was neglected even down to their clothes which were to be 'large and loose in order not to impede movement' and care was to be taken about cleanliness and appearance. Pupils were to be allowed the greatest possible freedom in recreation hours 'for youth has need of movement, and to form men capable of action they must not be too restricted in infancy'. Finally, pupils were never to be cruelly used either verbally or by corporal punishment.

   If St. Germain's noble plan of education for the pupils of the Écoles Royales Militaires must have remained—like all such plans—something of a pipe dream in the inevitable absence of a sufficient number of enlightened teachers to carry it into effect, nevertheless it must have helped to soften some of the more objectionable features of the old, spartan, system of education which then obtained in France and elsewhere. In the case of those colleges under the direction of the congregation of St. Maur—as at Auxerre—it reinforced attitudes and methods which had already been put forward some twenty years earlier by Dom Fougeras at a general chapter of the Benedictines at Marmontiers in 1758 (Challe (1); Moiset; Taton (3)).

8. The Benedictine teaching congregation of St. Maur, under whose control the École Militaire at Auxerre had been placed, had been founded by letters patent of 1618 confirmed by papal bull of 1621, and had been effectively instituted by Dom Gregoire Tarisse (born Cassenon 1571) who gave the new congregation its solid foundation and first lustre. This was later increased by Dom d'Archery, the founder of the Benedictine historical school, whose first and best-known pupil was Dom Mabillon. The centre of the congregation was in Paris, the residence of the superior general being in the Abbey of St. Germain des Près which also housed the magnificent library of the order. St. Germain des Près thus ultimately became the centre of a vast co-operative work of historical research leading to the gradual publication of imposing scholarly works such as *Gallia Christiana* (1715–1725) and *Histoire Littéraire de la France* (1733–1768). Fourier's strong historical sense was no doubt derived from the Benedictines. The considerable destruction of records and manuscripts of all kinds during the Revolution rendered the historical labours of the Benedictines doubly valuable. The members of the congregation of St. Maur moved freely from one Benedictine college to another, one reason, no doubt, for the active and progressive pedagogical attitude of the congregation. This became especially marked in the second half of the eighteenth century particularly after the expulsion of the Jesuits from France in 1762. The most progressive centre seems to have been in Sorèze beginning with the advent of Dom Fougeras as principal in 1757. Some idea of his enlightened attitude to education can be gleaned from the following extract from a memoir presented by him to the general chapter of the Benedictines at Marmontiers in 1758:

   > In a well-regulated college amusement should be mingled with work; it is essential

> that children acquire the habit of work without becoming disgusted by it: and one may avoid this happening by allowing them to distract themselves by some quarters of an hour of real recreation.

Other indications of the progressive attitude of the teaching at Sorèze and at other colleges of the congregation of St. Maur were the reduction, and in certain cases abolition, of Latin, the introduction of 'courses' in which pupils were free to follow subjects of their own choice, and also the emphasis given to the teaching of mathematics and science. This last tendency had already manifested itself before 1776, but became more marked with the arrival of pupils destined for the artillery and engineers for whom these subjects were of much greater importance than for the average pupil (*Gde. Encycl.* Taton (3)).

9. A seminary or college was opened in the priory of Sorèze in 1683. It was closed under various pretexts in 1722 and was not reopened again until 1757. The then prior, Dom Fougeras, was too daring in his reforms and was recalled in 1760. But on the insistence of parents his successor was ultimately forced to reintroduce some of the measures of his predecessor, and under Dom Despaulx, prior from 1766 to 1769 and 1771 to 1790, the enlightened reforms of Dom Fougeras were completely reinstated. By 1767 the college had become famous throughout France and beyond. In that year there were 220 pupils of whom seventy-two were foreigners. In 1789 there were no fewer than eighty Americans at the school. In 1812 the number of pupils was 223 of whom only six were Americans and eleven Spaniards, but by 1816 the total number of pupils had increased to 410, forty-three being Americans and eighteen Spaniards. In 1790 the school was split over the question of the oath of allegiance to the State; twelve of the original total of about twenty-four teaching staff refused to take the oath, while five swore it with reservations. Dom Despaulx left at this time and ultimately there remained only 4 brothers including François Ferlus under whose guidance the school managed to survive the storms of the Revolution. Some idea of the standing of the school can be seen from the fees which were 700 livres per annum compared to 500 at the school attended by Napoleon at Brienne, while the fees at other colleges of the Congregation of St. Maur were considerably less. Sorèze had many distinguished pupils; as Ferlus said during the Revolution: 'the pupils of Sorèze people all the corps of engineering, artillery, and marine and all classes of society which require extended knowledge'. Between 1805 and 1840 the school sent no fewer than 113 pupils to the École Polytechnique (Combes; Taton (3)).
10. Keralio, L. F. G. Chevalier de (1731–93). After service in the army he took up writing and acted for a time as tutor to the young Don Ferdinand of Parma in company with the philosopher Condillac. He was appointed professor of fortifications at the old École Militaire in Paris where he was very successful. A supporter of moderate reform at the time of the Revolution he was appointed a commandant of a battalion of the national guard in Paris. He was a member of the Académie des Inscriptions and was one of the editors of the *Journal des Savants* up to its suppression in 1792 (*Bio. Gen.*; *Bio. Univ.*; *Gde. Encycl.*).
11. Charbonnet, P. M. (1733–1815). He entered the Church and became professor at the Collège Mazarin. In 1762 he carried off the prize of master of arts at the University of Paris of which he was elected rector in 1781. At the Revolution he took the oath of allegiance to the state and occupied several municipal positions. He was chosen to oversee the imprisonment of the royal family in the *Temple*. Opinions have differed on the manner in which he carried out this delicate mission. On the creation of the Écoles Centrales he was appointed professor at Aube, and later at the Collège Charlemagne where he continued to teach till his retirement (*Bio. Gen.*; *Gde. Encycl.*).

12. See below Letter III, n. 4.
13. Bailly, J. S. (1736–93). By 1760 he had become immersed in his true vocation of astronomy. He entered the Académie des Sciences in 1763 and ran for the position of permanent secretary with the support of Buffon, but was defeated by Condorcet who was supported by d'Alembert. His great *Histoire de l'Astronomie* appeared between 1775 and 1787. In 1777 he made the acquaintance of Benjamin Franklin who appreciated his taciturnity and whose friendship and counsel prepared Bailly for his rôle in the Revolution. In 1783 he entered the Académie Française. He was elected first deputy of Paris to the States General, and as president of the National Assembly guided the Revolution through its first vital stages. He presided over the great day of the Tennis Court, claiming the right as president to be the first to take the oath. He was elected the first mayor of Paris on the same day (15 July 1789) as Lafayette was put in command of the *Garde Bourgeoise* (later National Guard). In spite of his glorious part in the early days of the Revolution he rapidly lost his popularity with the people of Paris as a result of his support for the King after the flight to Varennes, and even more for his part in the death of the republican 'martyrs' of the fusillade of the Champs de Mars on 17 July 1791. He resigned his position of mayor in November 1791 and retired to Nantes. Later he moved to Melun to be near his friend Laplace. Towards the end of June 1793 he was arrested and later condemned to death by the Revolutionary Tribunal and guillotined (*Bio. Gen.*; *Gde. Encycl.*; see also Brucker, Hahn (2), and Smith).
14. Bézout, E. (1730–83). He became a member of Académie des Sciences in 1758. In 1763 he was appointed examiner of the *gardes de la marine*, and was charged by the minister to compose a suitable textbook for the use of pupils. There resulted his *Cours de mathématiques à l'usage des gardes de la marine* (4 Vol., Paris 1764–7). In 1768 he succeeded Camus as examiner for the artillery. His *Cours complet de mathématiques à l'usage de marine et de l'artillerie* (6 Vol., Paris 1780) was immensely and deservedly popular and up to the end of the century was almost obligatory reading for pupils ambitious to enter the École Polytechnique. His *Théorie générale des équations algébraiques* (Paris, 1779) opened up the way to further advances and was probably the starting point for Fourier's own researches in the same field (*Bio. Gen.*; *Gde. Encycl.*; see also Vinot).
15. Bossut, C. (1730–1814). After a brilliant career with the Jesuits he became a student of d'Alembert with whom he later collaborated on the mathematical part of the *Encyclopédie*. In 1762 a memoir on the resistance of fluids to the motion of planets gained him a prize of the Académie des Sciences of which body he became a member in 1768. His *Cours complet de mathématiques* appeared in 1765, and his *Mécanique en général* in 1792. As professor of mathematics at the school of Mézières he transformed the quality and content of the courses. Among his pupils at Mézières were Borda and Coulomb (*Bio. Gen.*; *Gde. Encycl.*; *Ind. Bio.*; see also Doublet).
16. At Sorèze we know that the course of Camus was followed from 1758 onwards till its replacement by the course of Bézout in 1769. That Bézout was used at Auxerre as well as Sorèze is evident from the reference to that work in the second letter of Fourier to Bonard. In 1774 Bossut's course was added at

Sorèze and it was evidently also in use in Auxerre for in 1783 a certain Bonard the elder obtained first prize for 'le grand cours de Bossut'. In the same year Fourier was awarded equal first prize in Bossut's *Mécanique*. The works of Bézout and Bossut prove that the teaching of mathematics in the Écoles Royales Militaires was capable of reaching what would still today be regarded as an advanced school level. There can be no doubt that through their teaching and writing Bossut and Bézout made an important contribution to the great flowering of French mathematics and science in the revolutionary period. As regards the teaching of calculus this was facilitated in Sorèze (and possibly in other schools) by the introduction of Antelemy's French translation of Agnesi's work on the differential and integral calculus (Taton (3)).

17. Challe thought this long delay was due to opposition to the school at Auxerre being put under a religious body again, whereas Moiset considered it was simply an expression of the displeasure at certain pro-Jesuit measures introduced by the King. Whatever the reason for delay the edict was ultimately registered only at 'the very express commandment of the King'.
18. Nicolas Davout (1770–1823), later marshal of France, entered the same year. Fourier is said to have protected Davout's mother during the Terror.
19. This detail of the candle story is taken from Fortin (p. 106).
20. Municipal Library Auxerre item SZ 171.
21. Fourier Dossier, AN.
22. J. B. M. Champion de Cicé (1725–1805) was deputy for the bailiwick of Auxerre at the States General where he voted for the right. His much more famous brother J. M. Champion de Cicé (1735–1810) Archbishop of Bordeaux (1781) was a member of the Assembly of Notables in 1787. He showed himself a strong partisan of the popular cause in the debates on verification of powers of May/June 1789, and was one of the clergy who joined the third estate on 22 June. He was rewarded by the position of Lord Privy Seal in the liberal ministry formed by the King after the recall of Necker, and continued in office till November 1790. After ten years of exile he returned to France under the consulate and died as Archbishop of Aix, unlike his brother who died in exile (*Gde. Encycl.*).
23. Although Roux insisted on the veracity of this story, Cousin (p. 2, n. 1) argued that there was in fact no such boycott of non-noble students entering the specialized corps of the army, a view confirmed by a statement of the Abbé Proyart, principal of the college of Puy, in 1785; 'today the great ambition of the commoner is to see his son appear in uniform beside the nobleman's son' (Taton (3), p. 104).
24. Bonard, C. L., born around 1765. Commenced teaching at the École Militaire at Auxerre around 1784. He figures as professor of mathematics on a list of teachers at the college proposed by the director Dom Rosman in 1790. Bonard was a moderate republican, one of the signatories of the patriotic address to the National Assembly of the Society of Friends of the Revolution in Auxerre on 15 October 1792, and a member of the Revolutionary Committee of Auxerre. He was 'disarmed' in the spring of 1795 for his part in local government during the Terror, but was reinstated the following autumn. He did not attend the École Normale, presumably due to family commitments. He was appointed mathematics teacher in the new École Centrale at Auxerre in 1796, and was a member of the council of that school in 1800. In April 1804 he refused the position of professor of mathematics offered to him at the projected secondary school of Auxerre. Thereafter he gave lessons in mathematics till his retirement. He died in 1819 (*Arch. Yon.*; Cestre (3)).

25. See below Letter I, Appendix, p. 243.
26. It must be remembered that Fourier went to St. Benoit in a double capacity: to study for his noviciate, and to assist with (or more probably direct) the teaching of elementary mathematics to the other and less mathematically qualified novices. So that when he says 'we shall soon be at fractions' he is speaking as teacher rather than taught.
27. See below Letter I, n. 9, Appendix, p. 246.
28. See below Letter I, n. 11, Appendix, p. 247.
29. Lagrange was never an inspector of the Écoles Militaires as opposed to Bailly and Legendre. It is inconceivable that the latter would have spent so much time visiting the various schools. For a biographical note of Lagrange see below, Letter I, n. 12, Appendix, p. 247.
30. There were two *Journal de Genève* appearing in 1788. One only appeared between August 1787 and January 1791 and was purely a depot of facts and information relating to the district of Geneva. The other, founded by Panckoucke under the title *Journal historique et politique* (45 Vol., 1772–83), and continued by Mallet du Pan the elder (16 Vol., 1784–7), was given the title *Journal historique et politique de Genève* (18 Vol., 1788–92). During its last period the printed cover bore the sole title *Journal de Genève*. Fourier is evidently referring to this latter journal. According to E. Hatin (*Bibliographie historique et critique de la presse périodique française* (Paris 1866, p. 73)):

    > The long duration of this sheet, founded by Panckoucke, which had the advantage of appearing three times a month, sufficiently proves the regard in which it was held by contemporaries: it can be consulted as a faithful *resumée* of all the gazettes and public papers of the period.

    Fourier would therefore have been well informed of events in the external world at least up to the time of the surrender of his subscription.
31. The meeting of the assembly of clergy took place in the church of the Cordeliers, Orléans, from 17 March to 2 April, 1789. From the minutes of this meeting (which have been preserved in MS. 993 *Bib. Mun. d'Orléans*) it appears that the prior of the Abbey of St. Benoit, Dom Charpentier, played a leading part in the proceedings: he was a member of one of the bureaux for verifying the credentials of delegates, was one of twenty-six commissioners responsible for drawing up the *Cahiers de doléances* of this assembly, and was elected scrutineer at the election of delegates from the assembly to the States General. He himself proclaimed the results.
32. See below Letter II, Appendix, p. 250.
33. See below Letter III, Appendix, p. 253.
34. Cousin, p. 2.
35. Challe (1), p. 227.
36. 28 October 1789.
37. It was confirmed in principle at the sitting of the Assembly of 13 February 1790.
38. Mauger, p. 271.
39. See Navier's Introduction to Fourier's *Analyse des équations déterminées*. Paris, 1831.
40. *Arch. Dep. Yon.* Série. L, Reg. p. 223.
41. *Idem.*

42. See below Letter XII, n. 5, p. 294.
43. In his letter of 24 Nivôse Year II demanding the place of librarian in a projected new municipal library Fourier states that he had occupied successively the chairs of mathematics, history, eloquence, and philosophy.
44. Mauger, p. 271.
45. The Society of Emulation of Auxerre was founded in 1790 by thirteen young men of the town. Fourier was first president and probably the moving spirit of the foundation. The society was dispersed towards the end of 1791, no doubt due to widening political rifts between its members. The aim of the society was the culture of letters and arts. Its papers are in the possession of the *Société des Sciences Historiques et Naturelles de l'Yonne* (Quantin).
46. According to a *curriculum vitae* in his application for a retirement pension after the Hundred Days, Fourier was professor of mathematics for a time at the École Royale Militaire at Rebais, also under the congregation of St. Maur.
47. It is reproduced in Cestre (1) and embodies the liberal traditions of the Congregation of St. Maur.
48. Challe (1), p. 227.
49. By name Paradis, in the absence of Michel Lepelletier by that date deputy of Yonne at the Convention for the district of St. Fargeau. These and other details of the visitation are taken from Schmidt. For some indications of Lepelletier's curious career see note 53 below.
50. Lebeuf, vol. 2, p. 538.
51. Maure, Nicolas Sylvestre (1743–95). A grocer in his native town of Auxerre. While an administrator of the department of Yonne he was elected to the Convention through the influence of Michel Lepelletier. An unsuccessful mission to Eure et Loir in November 1792 led to a rebuke from the Convention, but he was supported by the Jacobin Society of which he was an active member. He voted for the death of the King and against an appeal to the people, or a stay of justice. He was president of the Jacobin Society on the day of the King's execution on 21 January 1793. He attempted a reconciliation between the Girondists and the *Montagnards* in March, but when he saw that this was impossible he demanded that the Society of Jacobins should inform the people of the situation in the Convention. He became a member of the Committee of General Security on 25 March 1793 and was largely responsible for its 'purification' and renewal the following September. He oversaw the *levée en masse* of 23 August 1793 in the department of Yonne, and on 29 December 1793 he was charged with the organization of revolutionary government in the departments of Yonne, Seine, and Marne. He remained faithful to the Mountain during the reaction after 9 Thermidor defending the former members of the Committee of Public Safety in a writing entitled '*Un mot à la décharge des trois membres de l'ancien Comité de salut public*'. Having shown himself favourable to the insurrection of 1 Prairial Year III (20 May 1795) he was denounced by Le Hardy on 1 June as a former friend of Robespierre and Dumas and a defender of Carrier. On 4 June the municipality of Auxerre revealed a series of (supposed) cruelties and exactions committed by its own representative. Maure then knew what fate awaited him and blew out his own brains.

    Although Maure was for a time a close follower of the bloodthirsty Marat, and congratulated himself at a sitting of the Jacobins on 26 January 1794 that Marat had called him his son, he seems to have been very moderate in his actions. Thus he had the French diplomat E. de Maulde acquitted on a charge of treason on 22 June 1793, while on October 1794 he was actually denounced by Garnier of Aube for having released from prison twenty-six non-juring priests and eleven wives of *émigrés*. The fact that he was painted as a bloodthirsty monster by Fréron a few days later can safely be discounted. The judgement of Kucinski seems closer to the truth: 'Such was Maure in his missions, protector of the poor, the unfortunate, he did nothing but good in the departments where he had to exercise power' (*Bio. Univ.*; *Bio. Gen.*; Kucinski).

52. I am indebted to Monsieur André Casimir of Joigny, Yonne, for the following details of the Popular Society of Auxerre. Unfortunately the scarcity of documents has made it impossible for Monsieur Casimir to write a detailed history of the society.
53. Le Pelletier de St. Fargeau, Louis Michel (1760–93). A member of one of the most distinguished families of the legal aristocracy, he occupied successively the positions of advocate-general and president of the *Parlement* of Paris. He was nominated to the States General by the nobility of Paris and was one of those who refused to obey the King's order of 27 June 1789 to join the third estate, eventually remaining alone in the noble's chamber with the Count Mirepoix. But the events in Paris of 12 July, and the pleadings and menaces (it is said) of the party of the Duke of Orléans persuaded him to make an abrupt change of front. From being an extreme reactionary he became a fervent revolutionary. On 13 July he strongly supported the recall of Necker saying: 'Let us represent the people if we do not wish the people to represent themselves.' In January 1790 he became a member of the Committee of Criminal Jurisprudence, and presented a sort of penal code to the Constituent Assembly in April 1791. Like Robespierre he was at this time a fervent opponent of the death sentence. On the dissolution of the Constituent Assembly he had himself elected president of the administration of the department of Yonne in which he had great influence through his vast domains in the district of St. Fargeau. Later he was elected one of the representatives of Yonne at the Convention where he played a leading part in the judgement and sentence of the King. Said originally to have been in favour of imprisonment, it has been conjectured that the same fear which had changed his mind on 12 July 1789 now led him to support the death penalty. In addition he showed himself one of the most vigorous opponents of an appeal to the people, publishing a pamphlet which Pétion—previously more of an opponent of the King than Lepelletier—denounced in the Convention as seditious. Lepelletier was assassinated on the eve of the King's execution. He seems to have been a curious mixture of genuine concern for his fellow men—among whom he had the capacity for inspiring deep loyalty and affection, as in the case of Maure—and a cynical and utterly realistic regard for his own interest: 'what do you expect,' he is supposed to have said, 'when one has 600 000 pounds of rent one has either to be at Coblentz or at the top of the Mountain'. Lepelletier, like Phillipe Égalité, Duke of Orléans, chose to be at the top of the Mountain. Whether, unlike the Duke, he would have been able to retain his seat there if he had not been assassinated on 20 January 1793 provides an interesting topic for historical speculation (*Bio. Gen.*; *Bio. Univ.*).
54. Gautherot, Claude (1769–1825). A painter and sculptor, he became popular for his busts of Voltaire, Rousseau, Turgot, and Bailly. He entered the *atelier* of the painter David in 1787 and became his friend. In 1790 he was a member of the administrative commission of the Jacobin Society where he presided

over the important sitting of 21 June 1791 at the time of the return of the royal family from Varennes. Having arrived in Auxerre with Michel Lepelletier in the autumn of 1791 he became a member of a departmental surveillance commission set up following a visit of two commissaires of the Paris commune after 10 August 1792. Later it required a special decree of the Convention (13 Vendémiaire Year IV) to free Gautherot from the attention of a judge of the peace curious to know the role he had played in the riot of 19 August 1792 in which two innocent men were murdered. He was attached to Maure in his mission to Seine, Marne, and Yonne. After 9 Thermidor he left Auxerre and installed himself in Paris. He was wounded by a bullet when defending the Convention on 13 Vendémiaire Year IV and thereafter devoted himself entirely to painting. He collaborated as editor in a collection of portraits of famous men and women of the seventeenth and eighteenth centuries in *Gallérie Française*, 3 Vol. (Paris, 1830) (*Bio. Gen.*; Casimir).

55. *Arch. Nat.* C 238, dossier 242, p. 14.

56. Reproduced in Porée, vol. 1, p. 115. It is against the motion—many times passed in the Convention and as many times repealed—to set up a special guard made up of recruits from the departments to take the place of the Parisian national guard and the armed guards of the sections which (rightly) inspired no confidence in their ultimate loyalty to the Convention among the Girondists and their allies.

2

FOURIER AND THE REVOLUTION: AUXERRE

1. The revolutionary vortex

In a letter written later[1] from prison, in justification of his part in the Revolution in Auxerre in 1793 and 1794, Fourier describes the growth of his political views:

> The first events of the Revolution did not change my way of life. Because of my age I was still unable to speak in public; and impaired by night studies my health scarcely sufficed for the work my position required of me.
>
> From another point of view I will admit frankly that I regarded these events as the customary disturbances of a state in which a new usurper tends to pluck the sceptre from his predecessor. History will say to what extent this opinion was justified. Republican principles still belonged to an abstract theory. It was not always possible to profess them openly.[2] As the natural ideas of equality developed it was possible to conceive the sublime hope of establishing among us a free government exempt from kings and priests, and to free from this double yoke the long-usurped soil of Europe. I readily became enamoured of this cause, in my opinion the greatest and the most beautiful which any nation has ever undertaken.

In such a mood of generous enthusiasm it was but a short step for Fourier to enter politics itself. The occasion of this would seem to have been a speech about conscription before the local Assembly following the Decree of 21 February 1793 for the raising of 300 000 men. On 1 February 1793, on the report of Brissot, war had been simultaneously declared on England and Holland. The previous day the annexing of Belgium had been decreed by the Convention on the motion of Danton. These new threats to the European *status quo* had led in turn to the formation of the first coalition against France. At the same time massive desertions by the volunteers of 1791 and 1792 had reduced the Army of the Republic to around 228 000 men as against the 400 000 under arms in December 1792. It was to remedy this perilous situation that it was decided to raise a *levée* of 300 000 men. But the Convention only fixed the individual totals from the various departments and left it to local bodies within departments to decide by the vote of citizens how their individual quotas should be filled, whether by lot, by volunteering, or other means. This large uncertainty as to the means of choosing 'volunteers' inevitably led to heated discussions in local assemblies throughout the country. In Auxerre the question was debated in a general assembly of the sections of the commune, and it was apparently at this meeting that Fourier intervened with a plan for filling the local quota which was later adopted by the assembly. It was as a result of the favourable impression thus created that Fourier was then invited to join the local Popular or Patriotic Society.[3]

Fourier himself gives a different—though not necessarily contradictory—account[4] of the manner of his involvement in local politics in the spring of 1793: although he had already become strongly imbued with republican ideals his duties as a teacher had prevented him from undertaking any additional duties. But when the law of 21 March 1793 had decreed the establishment throughout France of sectional committees to receive the 'declarations of strangers and travellers' he was invited to become a member of the local committee in Auxerre by a general assembly of the sections. Fourier might conceivably have turned down this invitation, and later he must often have wished that he had. But at the time the temper of patriots everywhere had been raised to fever pitch by the military reverses in Belgium culminating in the defeat of Dumouriez at Neerwinden. The mounting military threat from without, combined with the internal threat posed by the rebellion in the Vendée, then led to a series of revolutionary measures—including the institution of the Revolutionary Tribunal—carried in the Convention against the fierce opposition of the Gironde. For Fourier to have refused to accept the position offered him on the local committee of surveillance would therefore have branded him as an opponent of the patriot party. In fact, what is known of his later involvement in local politics makes it likely that he eagerly embraced the chance to play his part in the defence of the Republic 'one and indivisible' against all its enemies, internal and external.

Once a member of this committee, however, he inevitably found himself sucked into the revolutionary whirlpool, in the first place, perhaps, in putting into practice his own plan for local recruitment. It was one thing, in fact, to decree the raising of 300 000 men, and even to agree in local assemblies (as in Auxerre) on methods of meeting local quotas. It may not even have been too difficult to raise the local quotas in towns such as Auxerre where there were strong radical tendencies and no great opposition to the central government. It was quite another matter to persuade recruits to come forward in many of the country areas. In the hope of ironing out these tiresome local difficulties some eighty-two members of the National Convention were sent out from Paris on 9 March to oversee the *levée*. An insurrection in Brittany was quickly suppressed, but in the Vendée the opposition of the peasant masses soon led to a full-scale royalist revolt which only began to be controlled in October 1793, and then only by means of the most draconian measures, and after government forces had suffered a number of major reverses. Thus the attempt to raise 300 000 men led to an even more pressing need for recruits in those parts of France which had not suffered from insurrections, arising in part out of the very attempt to impose the *levée*. This helps to explain a mission on which Fourier was sent in June 1793 from Auxerre to the neighbouring district of Avallon 'to invite, and if necessary require, citizens to take arms against the rebels of the Vendée'.[5]

Fourier had been sent to Avallon by the *conventionel* Meaule,[6] then on a mission to oversee the *levée* in the departments of the centre and west. A little later, on 1 July, he was representing Meaule at a meeting of all constituent authorities in Auxerre.[7] By this time, therefore, when the struggle between the Federalists and the Jacobins had reached a new paroxysm of fury, Fourier had evidently fully committed himself to the Jacobin cause. Things had moved a long way since the decree of 21 February for the raising of 300 000 men: on 10 March the Revolutionary Tribunal had been instituted; on 11 April the rate of the assignat had been pegged; a maximum price for grain had been laid down on 4 May; and finally the insurrection of the 31 May–2 June had led to the fall of the Gironde followed by the Federalist revolt. At one point this revolt had spread to no less than sixty departments. During June and July both the Federalists and the Vendéens continued to prosper and for a time in July the life of the Republic was in jeopardy. All this time, as Fourier remarks in his letter to Villetard:

> the duties of these committees [of surveillance] were successively modified, and various laws entrusted them with a universal surveillance which soon degenerated into very extensive powers since the law of 17 September ordered them to proceed to the arrest of suspects.[8]

Thus by 17 September the committees of surveillance—originally entrusted with the comparatively inoffensive task of keeping an eye on the movements of strangers and travellers—had become an integral part of the apparatus of the Terror which had itself been forced on an unwilling government and Convention by the mounting tide of popular agitation impelled forward by near famine conditions and the continuing military threat from within and without. At this point Fourier prudently attempted to withdraw from the committee feeling 'less suited than many others to execute this law'[9] (that of 17 September) to the extent of submitting his resignation in writing. But his attempt was in vain, willy-nilly—and it is not certain that the feelings expressed in Fourier's letter to Villetard in 1795 were exactly the same as those he harboured in the heady days of September 1793—he was inextricably caught up in the revolutionary vortex. For as he relates:

> This move [his letter of resignation] produced an effect opposite to what I had

> intended. In the reply sent to me I was reminded of a law which forbade any official from abandoning his post, and my resignation was rejected. At the same time other persons openly accused me of abandoning my colleagues at a moment when my help was about to become most useful to them. I was reproached with the feebleness of my conduct, and some even doubted the purity of my intentions.[10]

Thereafter one might have expected his zeal for the revolutionary cause to have abated somewhat. Nevertheless on 12 October, some three weeks after the promulgation of the notorious law of 17 September, Fourier was sent by Nicolas Maure on a mission to the neighbouring town of St. Brie 'to bring the people back to a sense of duty'[11]—in all probability in connection with the excessively unpopular measures for raising men for the *levée en masse* of 23 August 1793. It is not known how successful Fourier was in his attempt to reform the people of St. Brie, or even if he went there at all, for a few days later he was sent on another, much more important and as it turned out far more dangerous, mission to collect horses for the war effort in the neighbouring department of Loiret.

2. The Orléans affair

Fourier had been delegated by the *conventionel* Ichon,[12] one of a number of representatives of the people sent out by the National Convention following its decree of 17 Vendémiaire Year II (8 October 1793) relating to the raising of horses in urgent demand as a result of continuing military operations in the Vendée and elsewhere. Ichon was assigned to the 19th military division comprising the departments of Yonne, Aube, Côte d'Or, Nièvre, Loiret, Cher, and Indre, and set up his headquarters at Auxerre. With the help of the local Popular Society[13] he chose six agents, one of whom was Fourier, to oversee the collection of horses, the terms of reference of their mission being laid down in an order[14] dated 23 Vendémiaire (14 October 1793): they were to be responsible solely for the raising of horses (article 3), were to concert with local popular societies and envoys of popular assemblies (article 4), and were also expected to act with great speed as their powers were to expire a little less than a month later on 21 Brumaire (11 November 1793).

Fourier evidently carried out his duties in Loiret with commendable dispatch for his mission had already been completed 'with every possible success' by 7 Brumaire (28 October 1793), as appears from a letter[15] of that date written by Fourier to Bonard from the Angel Inn at Montargis, a small town some seventy kilometres from Auxerre. But on his way through Orléans in the course of his mission Fourier had unfortunately become involved in a local dispute which was to have the most distressful consequences. He alludes to this affair somewhat obliquely in his letter to Bonard:

> You will have heard that the Department of Loiret is not absolutely quiet and the town of Orléans is somewhat disturbed: I played some part in this matter and I behaved in it in conformity with the principles of the Revolution.

But the 'principles of the Revolution' varied considerably not only from one 'party' to another but even within a given 'party'. To understand why Fourier's revolutionary principles had led him into such serious trouble the reasons for the 'somewhat troubled' state of the town of Orléans in the autumn of 1793 must first be elucidated. Thanks to Lefebvre,[16] these reasons are known in great detail and provide one of the more curious and interesting examples of the actual working of the French revolutionary process in a specific case.

Like many other French towns, Orléans had been in an increasingly troubled state from at least March 1793 onwards due in large part to local antagonism between the wealthy Bourgeoisie, supporters (*faut de mieux*) of the Girondin cause, and the *sans-culottes*, the small tradesmen and artisan class who were equally firm supporters of the revolutionary groups to the left of, and including, the Jacobins of the spring 1793 variety.[17] The antagonism had been exacerbated by rising prices, shortage of bread, and recruitment for the *levée* of 300 000 men. On 15 March the situation took an ugly turn when two (radical) representatives on mission (Jeanbon-Saint André and Lacoste) were insulted by members of the Bourgeoisie on their way through the Faubourg Saint-Marceau. A much more serious incident occurred the following day when the representative Leonard Bourdon—later to play a leading part in the downfall of Robespierre—was set upon and wounded in the centre of the town. His wounds were not grave and he soon recovered, but word went round that there had been an attempt on his life. In the circumstances of the time—the Vendée was then on fire—the 'assassination' of Leonard Bourdon seemed part of a great counter-revolutionary plot. On 18 March the Convention voted Orléans in a state of rebellion, suspended the municipality, and decreed that the guilty be sent to the Revolutionary Tribunal. It also detailed three representatives of the people, Bourbotte, Julien of Toulouse, and Prieur of the Marne, to proceed to Orléans. However, two other representatives, Collot D'Herbois and Laplanche,[18] already on mission for recruitment in Nièvre, reached Orléans first and set about 'revolutionizing' the town. On 24 March the Girondins with the aid of Tallien had the decree of the Convention lifted only to see it re-imposed on 27 March following a protest from Collot and Laplanche. Thereafter the municipal authority was in the hands of the *sans-culottes* and although the Bourgeoisie of Orléans moved heaven and earth to have the decree of the Convention withdrawn they were unable to do so before the insurrection of 31 May finally consolidated the power of their opponents. On 13 July—the day of Marat's assassination—nine of the *suspects* of the 'assassination' of Leonard Bourdon who had been sent before the Revolutionary Tribunal were condemned to death and guillotined.

Laplanche returned to Orléans on 1 September, this time entrusted with the overseeing of the *levée en masse* of 23 August and with orders to renew the administration and purge those suspected of federalism. During August the power of the *sans-culottes* and their more extreme leaders, especially Taboureau, the so-called *enragé* of Orléans, had increased steadily due mainly to a chronic shortage of food accompanied by a vertiginous rise in the prices of all basic commodities and a corresponding devaluation of paper money. In these respects the situation in Orléans was typical of that in other parts of France. On 26 July, under pressure from the near-starving populace, the Convention had been forced to bring in a law against hoarding according to which merchants were required within eight days of its proclamation to declare their stocks of merchandise to the authorities and display a notice of the list of the various items outside their premises. Anyone who failed to fulfil either of these provisions, or who gave false information, was to be declared a hoarder and as such was liable to the death penalty. In Orléans the feverish attempts of merchants to sell their stock within the eight days allowed by the law led to the institution of forty-four commissaries who proceeded to domiciliary visits. These visits were very fruitful and resulted in the seizure of much undeclared stock, though no-one was prepared to pursue delinquents for hoarding and thus send them to the scaffold. Instead they were fined and their stocks confiscated.

Throughout August the crisis continued so that when Laplanche arrived in Orléans on 1 September the town was in a great state of ferment. At first it seemed that his arrival would assure the total and final triumph of the *sans-culottes*. He chose his advisers from among them in the Popular Society of the town. He declared that he was surrounded by twelve members of the 'club' whom he regarded as 'pure', that is, in a state of revolutionary grace. On 3 September and subsequent days he assembled the administrative corps of the city before the people in the church of St. Paterne and proceeded to 'purge' them after subjecting them to a torrent of vituperative abuse—no doubt from the pulpit of the church, a peculiarly appropriate 'platform' for an ex-member of the Benedictine order. He took the upper-middle class especially to task, and threatened to dismiss the whole departmental administration. He taxed the rich and distributed some—but not all—of the proceeds among the poor. He made numerous arrests including Bigot, the arch-hoarder in the eyes of the *sans-culottes*. On 9 September, at his third *séance* in St. Paterne, he even threatened to form a revolutionary army with a moveable guillotine like that in Paris. But in spite of his violent language and his war on the rich—which was real enough at first—Laplanche seems quickly to have taken a strong personal dislike to certain of the *sans-culottes* leaders, especially Taboureau, who may well have offended his vanity by their independent and truculent bearing, the special badge of the militant poor in all ages. On the other hand, those whom he had punished pocketed their pride and inundated him with humble supplications for the lifting of fines or terms of imprisonment. They found support among certain *Montagnards*—or self-styled *Montagnards*—in the administration. Especially helpful to the Bourgeoisie was Aignan,[19] a young and able man who acted as secretary to Laplanche in the *séances* at St. Paterne. Aignan seems quickly to have insinuated himself into the good graces of Laplanche to the point of becoming *procureur-syndic* of the district, no mean achievement for a former 'Feuillant' who was rumoured to have been the author of a tragedy on the death of King Louis XVI which had circulated clandestinely earlier in the year, and who was reproached—rightly, it seems—for having become a *Montagnard* in order to escape conscription for the *levée en masse*.

But the major influence in turning Laplanche against the *sans-culottes* in favour of the better-off members of society seems to have been the *conventionel* Delaguelle de Coinces.[20] By August 1793 De Coinces was taken for a backer of the *sans-culottes* but this had not always been the case. In 1789 he had been one of the judges who had condemned to death the notorious Rimbert.[21] After the 'Revolution' of 10 August 1792, the sentence on Rimbert had been quashed as illegitimate by the court of appeal, and after the fall of the Gironde on 2 June 1793 the court had taken a further step to the left by allowing his widow to take an action against her late husband's judges, her lawyers suggesting the sum of 150 000[22] livres as adequate indemnity for the loss of her husband, not forgetting legal costs. Rumour even had it in Orléans that the widow would only be satisfied with the blood of her husband's judges, and that the affair was to be taken up by the Revolutionary Tribunal. Since Taboureau had already defended the memory of Rimbert, de Coinces had a pressing interest in causing his downfall, an eventuality which became more probable in October when he gave his beautiful daughter Adélie in marriage to Laplanche. In the event Taboureau suddenly found himself not only without his promised place on the departmental administration but even excluded from the general council of the commune. Laplanche also attacked him at a meeting of the Popular Society of which Taboureau was at that time president. But the debate was adjourned and many of Taboureau's supporters continued to hold positions. And so having raised the expectations of the *sans-culottes*, Laplanche ended by disappointing and irritating them by his actions against Taboureau and his new-found gentleness towards their hated opponents among the merchant class. When Laplanche left for Bourges the *sans-culottes* returned to the attack, and when he returned to Orléans on 11 October the Popular Society pointedly failed to send a delegation to compliment him on his safe return. The representative of the people answered by freeing the arch-hoarder Bigot from whom he even obtained a loan for grain destined for the Navy, an act which caused the most intense annoyance. Laplanche in turn was furious at the *sans-culottes* who had, he said, profited by his absence to destroy the peace and quiet he had left behind him on his departure for Bourges. On 13 October, having assembled the people and authorities for one of his famous sessions in St. Paterne, he attacked two of the leading *sans-culottes*, Chamouillet and Besserve, for being oppressors of Bigot: 'It will be on the top of his sacks of corn that he will appear before you. Butcher him [there] if you dare!' The next day (14 October) there was a strong movement in the town against Bigot, and a violent altercation between some of the *sans-culottes* leaders and Laplanche, who thereupon rushed to the town hall where he dismissed Laguette, Billet, Chamouillet, and Besserve and had the first three arrested. The next day the most militant of the *sans-culottes* leaders, Taboureau, was arrested on the order of the Department and sent to Paris. It was at this singularly inappropriate point that Fourier chose to intervene and air his eloquence on the side of the *sans-culottes*. According to Fourier himself[23] it was 'the defence, perhaps imprudent but at least disinterested' which he dared make of 'three paterfamilias' which led to his disgrace. There can be little doubt that the paterfamilias in question were the above mentioned trio Laguette, Billet, and Chamouillet. Fourier's 'defence' of them at the Popular Society, before their arrest or afterwards at the time of their 'trial', was certainly imprudent. For these three had evidently incurred Laplanche's special wrath, so that by defending them Fourier was attacking the dreaded representative of the people on mission in the very capital of his district, a most unwise procedure, and one liable to lead to unpleasant consequences. These were not long in developing. By the time of his letter of 7 Brumaire to Bonard from Montargis he had already learnt that his adversaries in Orléans intended to denounce his conduct to Ichon as the person responsible for sending him on his mission to Loiret. In reality this denunciation had already reached Ichon the previous day as appears from a letter of 12 Brumaire to the Committee of Public Safety from the *conventionel* Nicolas Maure:

Liberty or death 12th day of Brumaire Year II

I was at Joigny, citizen colleagues, the sixth day of this month with Ichon when he received from a mounted gendarme a letter from the administrative body of Orléans demanding the recall of citizen Fourrier [*sic*] agent of Ichon in that department for disturbing the public order. My colleague immediately ordered the recall of Fourrier. However, he had seen his conduct reproved, and Fourrier recalled, without having been heard. I owe you an account of the method employed by Ichon for the nomination of his agents. When he arrived he said to me: tell me of someone in whom I can trust to speed up my operations in the departments assigned to me. I sent him to the Popular Society of Auxerre which is excellent. It chose six citizens who were presented to him and whom he accepted. Citizen Fourrier, a young man full of intelligence, eloquence and zeal, was sent to Loiret. Ichon conferred on him powers restricted to the collection of horses. It seems that Fourrier, finding no opportunity to display his eloquence before such audiences, got up on certain popular platforms. He can talk very well and if he put forward the views of the Society of Auxerre he has done nothing blameworthy; but he is awaited to give an account which will be examined severely.

Citizen colleagues, Ichon is a brave man. He is afflicted with this censure. He has done nothing to merit it. Let the Convention thunder at evil men but let her encourage the good. Listen to the voice of him who always speaks the truth and who loves you all after his own dear land. Give some consolation to Ichon who has already hired more than 600 fine horses and who takes infinite pains. Let the Convention be strong in the confidence of French men. Eight hundred thousand men, horses, munitions, all are ready at the moment, at the hour. So that were all the despots united as many again, I should not fear them.

Brotherly greetings
Maure the Elder.[24]

The reference in Maure's letter to the censure of Ichon is explained by the fact that the administrative body of Orléans complained about Fourier's behaviour not only to Ichon, but also to the Committee of Public Safety. This in turn led directly to a decree[25] presented to the Convention on behalf of the Committee by Barère[26] on 8 Brumaire. Article 1 of this decree reminded representatives of the people sent to departments for the raising of cavalry (such as Ichon), that neither they nor their delegates (such as Fourier) could countermand measures of representatives of the people already sent to departments (such as Laplanche). Article 2 stated that:

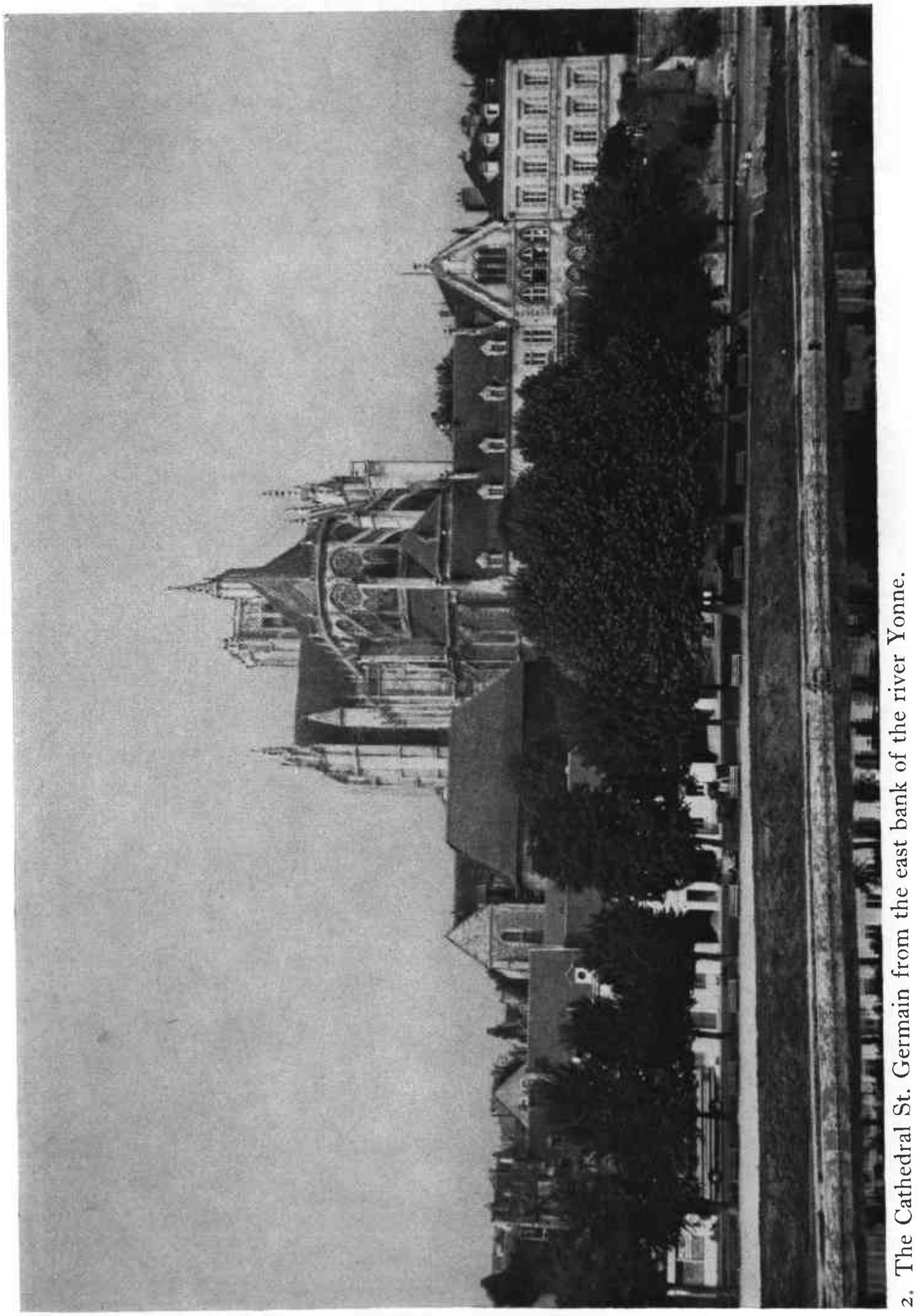
> The commission given by the representative of the people sent into the department of Loiret to citizen Fourrier [*sic*] is revoked. The citizen Fourrier is declared incapable of receiving such commissions [in the future].

Although Ichon was not explicitly named in the decree he was referred to by name in the account given in the *Moniteur*[27] in which Barère was reported to have taxed him with exceeding the terms of his mission. This was as good as a public rebuke by the Committee, and an unjustified one at that, for although Fourier had certainly exceeded the powers conferred on him by the terms of Ichon's order of 23 Vendémiaire, Ichon had certainly not exceeded his, the appointment of agents to oversee the raising of horses being allowed for explicitly in Article 10 of the Convention's decree of 17 Vendémiaire. Ichon, who in any case seems to have been an excitable fellow, was not unnaturally upset to read of the rebuke meted out to him by Barère, all the more so as he apparently first learnt both of the decree of 8 Brumaire and of Barère's strictures not in a letter from the Committee but in the *Journal des Débats*.[28] His displeasure at this unwarranted rebuke may possibly even have been mixed with fear, if not for his head, at least for his position. In any case he wrote[29] post-haste on 11 Brumaire to justify himself to the committee: he pointed out that the individual who had abused his powers in the Department of Loiret (that is, Fourier) had been appointed on the advice of the foremost patriots of the Popular Society of Auxerre; that he was justified in appointing agents by Article 10 of the law regulating his mission; and that his order regulating the powers of these agents gave them no mandate for 'contradicting or opposing the measures already taken by representatives of the people' in the department in question. There was, in fact, only one fault with which Ichon felt he could reproach himself, his failure to inform the Committee of the contents of this order. Otherwise the report of the Committee to the convention would necessarily have restricted itself to Fourier's errors. As it was, Ichon was evidently deeply wounded at what he interpreted as the censure of the convention:

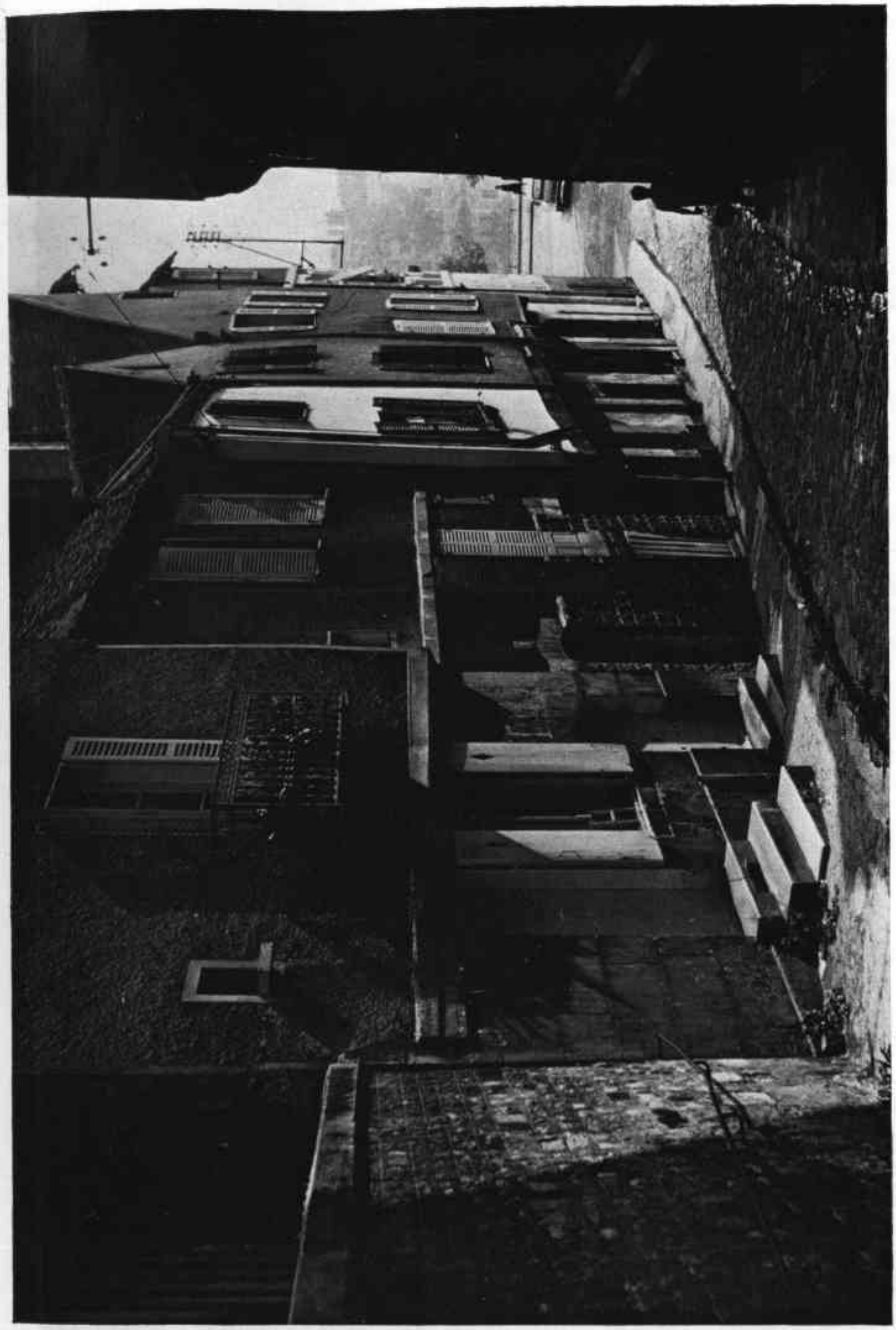
> Citizens and colleagues; the decree handed down by the Convention at the conclusion of the report of the Committee touches me at present to the quick. I am struck with the severity of its provisions.

He was evidently concerned above all with his reputation as a good *Montagnard*: 'I beg you', he said to the Committee, 'not to forget that I am entirely devoted to the cause of the state, and that there is nothing more precious to a *Montagnard* than to retain himself pure in public opinion.'

As an additional precaution he thoughtfully enclosed with his letter to the Committee an address[30] to the National Convention itself in which he briefly related the facts of Fourier's misconduct, the remonstrance by the 'regenerated administrative corps of Orléans', and his subsequent recall of Fourier. A reference at the end to 'several details of great interest' which made it necessary for the National Convention to 'order its Committee of Public Safety to take the most exact cognisance of the whole affair' might have sent an additional shiver down Fourier's spine if Ichon's address had been published in the *Journal des Débats*. But the address itself is next to his letter to the Committee in the Archives, and there is no indication it was ever read to the Convention.



2. The Cathedral St. Germain from the east bank of the river Yonne.



3. A street in the ancient part of Auxerre leading down to the river Yonne

Fourier's intervention in Orléans had evidently stirred up a regular hornets' nest and given him most unwelcome national press coverage as a man 'incapable of holding such commissions in the future'. October 29, thirteen days after the execution of the Queen, and two days before that of the Girondists, was hardly the best of times to be denounced in the Convention by Barère who had himself played a leading part in the proceedings against both the Queen and the Girondists. Nevertheless, judging by the tone of Maure's letter of 12 Brumaire, Fourier was by then no longer in any real danger. There is good reason to believe, however, that he *had* been in considerable, even grave, danger for a short time immediately after word of Barère's decree reached Ichon in Joigny. According to Cousin, Ichon then

> lost his head, and for fear that he would be accused of complicity with Fourier directed an order against him according to which he was to be arrested wherever he was and be guillotined on the spot.[31]

It might be difficult to attach much credence to this account if it were not for another—considerably later—letter of Maure to the Committee of Public Safety in which he enclosed

> an order of the representative Ichon which, among other dispositions, takes away the powers given to citizen Fourier sent by him [Ichon] as national agent into the department of Loiret, orders his transfer to Orléans and execution there, makes the most complete eulogy of this citizen, gives details of the events which led to this order being made, demands his punishment if he is guilty, his liberation if he is innocent.[32]

Unfortunately Ichon's order has been either destroyed or misplaced. Nevertheless Maure's abstract of it still conveys a vivid impression of Ichon's alarm and confusion at the news of the Convention's decree of 8 Brumaire and the criticism of himself contained in Barère's presentation of the decree. We gather that at some stage after Fourier's intervention in Orléans Ichon actually ordered his arrest, even his execution, though there is an evident contradiction between Fourier being executed and simply being tried and punished or released according as to whether he were guilty or innocent.

Cousin then rounds off the story: according to him when Fourier had completed his mission in Loiret he returned to Auxerre

> where he would have run the greatest possible danger if the Popular Society and the Committee of Surveillance had not interposed themselves between Ichon and him. Maure, deputy of the department of Yonne at the Convention, who was then at Auxerre, successfully intervened on behalf of his young and learned compatriot.

Cousin's account requires possible modification in one respect only. If in spite of being at Montargis on the seventh, Fourier had not returned to Auxerre at the time of Maure's letter of 12 Brumaire, it was because he too had got word of the Convention's decree of the eighth removing him from his commission (he could after all, like Ichon, have read of it in the *Journal des Débats*) and that he thereupon wisely decided to hide[33] for a while until he learnt how things had gone in Auxerre. No doubt the sum of 400 francs demanded from Bonard in his letter from Montargis was to cover just such a contingency.

As for Ichon, once he had cooled down he no doubt felt something of a fool for having over-reacted in such an excessive way to Fourier's behaviour in Orléans. Nevertheless, he was evidently still in no mood to exonerate Fourier completely, as appears from an order[34] promulgated by him at a *séance* of the departmental directory at Auxerre on 19 Brumaire. Having referred to his (Ichon's) order of 23 Vendémiaire (laying down the duties of the six commissioners appointed to oversee the collection of horses) and to the decree of the Convention of 8 Brumaire which declared Fourier incapable of holding such a commission in the future and directed the immediate recall of all commissioners, and considering that Fourier had betrayed the confidence of Ichon by exceeding the limits of his powers, it was ordered that

> citizen Fourrier [*sic*] sent by the representative of the people Ichon into the department of Loiret, and suspended from the exercise of his powers by Ichon on 7 Brumaire is and remains definitely dismissed . . .

Judging by the tone of this order, on 19 Brumaire (9 November, 1793) Ichon was evidently still smarting from his censure by the Convention. In fact from a letter[35] of 29 Brumaire from Maure to the Committee of Public Safety, we learn that although Ichon had been 'consoled' by a letter[36] sent him by the Committee, his peace of mind had not yet been restored and Maure felt he needed a rest. As for Fourier, the date of his return to Auxerre is unknown, nor is it known whether he was 'disciplined' in any way beyond being dismissed from his commission and declared incapable of holding any similar ones in the future. In any case he must have hoped—vainly as it turned out—that he had heard the last of his 'imprudent' defence of the three paterfamilias of Orléans.

3. Imprisonment of Messidor Year II

On his return to Auxerre, Fourier continued to teach in the college and remained a member of the local revolutionary committee. When he next appears on the scene it is in the guise of applicant for the new position of Municipal Librarian in Auxerre—a somewhat unexciting and stay-at-home assignment eminently suitable for a citizen forbidden to hold any further roving commissions. To the several reasons advanced by Fourier in favour of his candidature[37]—wide teaching experience, irreproachable morals, well known civic virtue attested by his election to a public position (membership of local Revolutionary Committee)—Fourier added a somewhat unorthodox 'need of several years repose' necessitated by his 'having devoted' himself 'since childhood, and possibly with too much ardour, to the study of the exact sciences', passing his nights in instructing himself, and his days in instructing others. A certain tone of lassitude is detectable in Fourier's 'need of several years repose' and the reasons advanced in its favour are not entirely convincing. Had he grown weary of the Revolution which he had embraced so eagerly in the preceding spring? Or was he simply suffering from exhaustion as a result of his horse-raising and other activities in Loiret? It is impossible to say: no letters written by Fourier in the year 1794 have been found beyond the one just referred to. Residing all that time in Auxerre, he would in any case have had little or no occasion to write. There is therefore no indication of his attitude to the political and other developments of the year. Was he perturbed at the so-called drama of Germinal, the execution of the *Hébertists* on 24 March and of Danton and his associates a few days later on 5 April? No doubt these events were as confusing to the 'patriots' in the provinces as they were to those in Paris. Had he begun to question the justification of a Revolution which could hound the mathematician and *philosophe* Condorcet to his death,[38] or which was soon to have no need of a scientist of genius like Lavoisier?[39] Both these events must surely have touched Fourier the mathematician and scientist more than other men. What were his feelings at the mounting holocaust of terror after the law of 22 Prairial had removed the last remaining checks of the due process of law before the Revolutionary Tribunal, so that the appearance of a name on the daily list of the State prosecutor Fouquier-Tinville was almost equivalent to a death sentence? Once again there is no way of knowing, no evidence beyond what Fourier himself wrote afterwards when he claimed that he had spoken out in Auxerre against the worst excesses of the Revolution.[40]

Although his application for the position of librarian was unsuccessful, he was designated in May by the Popular Society of Auxerre as one of the 'bibliographical commissioners'[41] responsible for overseeing the preservation and cataloguing of the many books which were at that time in danger of destruction following the suppression of the regular monastic orders and the break up of libraries belonging to *émigrés* and those whose goods had been confiscated by the state. In addition he continued to teach in Auxerre. In April 1793 the college had suffered its first major change of personnel since the outbreak of the Revolution when all the remaining so-called professor-priests apart from the principal, Rosman, were forced to resign through pressure brought on them by the Popular Society of the town. Rosman somehow managed to continue in office—possibly in a caretaking capacity—but in June he too had to step down. His place was then taken by Balme on the recommendation of Nicolas Maure.[42] The fact that the appointment was by the Minister of War, Bouchette, indicates that the college still continued as an École Militaire, but on 1 November 1793 it lost this status following a decree of the National Convention abolishing all such schools. From 1 November 1793 onwards the college continued as a National College and it was still in existence in June/July 1794 when a list of the staff included Fourier, Roux, and Bonard.[43] Soon afterwards it was closed down, as is attested by an order[44] of 29 Thermidor Year II (16 August 1794) requiring the settling of the accounts of the sale of furniture of the college—a good measure of the straightened circumstances of the departmental administration under whose control it then lay. Judging by his invariable position at the head of the list of professors of the school, Fourier acted as professor of the first class and possibly as vice-principal during the whole of Balme's principate.

In addition to his teaching and bibliographic duties Fourier continued as a member of the revolutionary committee of Auxerre. After his unsuccessful resignation bid around September 1793 he would have known better than to make a second attempt during the far more dangerous period of the spring and summer of 1794. A few glimpses of Fourier's revolutionary activities in Auxerre and district have survived, one in a story given by Cousin:

> as a member of the revolutionary committee of Auxerre Fourier had been entrusted with some mission or other to the neighbouring town of Tonnerre. On his way there he entered into conversation with another traveller in the public coach; seduced by the amiability of his questioner, this man told Fourier that he was also entrusted with a political mission to Tonnerre, but one of the gravest kind. It was a matter of having arrested and transferred to the Revolutionary Tribunal—which usually meant being sent to the scaffold—a person from Tonnerre whom Fourier scarcely knew but whom he had every reason to believe innocent. On leaving the coach at Tonnerre the agent was to demand the arrest of the person in question. Fourier attached himself to this man, insinuated himself more and more into his confidence, and on arrival at Tonnerre invited him to lunch at his inn: there he exerted all his charm to retain him and make him forget his mission. It was impossible to warn the intended victim, for it would have been necessary to confide in a servant who could have betrayed him; on the other hand if Fourier were to leave his man for a moment the latter would have gone straight to the municipality to demand the necessary armed guard to effect the arrest. Faced with this difficulty, and having exhausted every means of retaining his guest voluntarily, Fourier left the room where they were dining under some pretext. On going out he gently locked the door and ran to warn the person who was menaced with so imminent a danger. When Fourier failed to return the agent grew restless, made to leave the room, and finding himself locked in flew into a violent rage. Soon afterwards Fourier returned, excused himself as best he could for the silly joke he had played on the agent, and offered to lead him to the municipality. On the way they met the very man whom Fourier had warned who was now on his way out of the town. To distract the attention of his companion Fourier stopped before a newly painted shop sign and began to extol its beauty with an eloquence which held the eyes and mind of the agent on one side of the street while the suspect slipped past unnoticed on the other.[45]

Another glimpse of Fourier, this time as a somewhat embarrassed agent of the Terror in Auxerre, is contained in a passage from a letter, written in prison to his son, by a François Leblanc, former *procureur du roi* for waters and forests in Auxerre.

> About fifteen days ago, my good friend, Fourier came here with a second member of the Committee. He gathered us together and informed us that within eight days they had to send off everyone's interrogations and the reasons for their arrest, and that the representative Maure would shortly judge us either yonder or here: in order to save time he gave us a series of questions to answer on a *pro-forma* consisting of our names, titles, number of children, fortune before and since the Revolution. He warned us that further questions would be asked, that among others would be added questions on our voyages to Paris since May 1789 and on the various outstanding occasions [of the Revolution], on the petitions we may have signed, on our connections; the interrogations were commenced the same evening but were not exhaustive: for everybody they were restricted to very few things, to nothing at all as far as I was concerned. I was asked if I had been in Paris on any of the following occasions? No; where was I at the death of the tyrant? At Auxerre or in my country house; if I had signed any petitions? No; if I had done anything for the Republic? Some patriotic gifts and others to our brothers in arms, recently a bedcover and a horse saddle. Why had I given up my employment? Because I had for a long time intended to transfer my position to you, that I was not able to carry it out any longer because of my leg; since that was all, I suggested to them that they were doubtless going to ask me some questions on the offence which had given rise to my arrest. After looking at each other, especially Fourier who was asking the questions and writing notes at the bottom of my form, Maure spoke up and told me that there were no further questions and that I could give a memoir. I asked him on what. On my life since 1789 he replied; the whole thing went off very reasonably for everyone. Fourier said to me, you have a son in the armed forces of the Republic? You know I have, I replied. He wrote it down although it was already given as a reply to their questions concerning the number of children . . .[46]

By Messidor Year II Fourier had become president of the revolutionary committee in Auxerre. As such he was the foremost local agent of the

Terror in that town, and so might reasonably have expected to enjoy some immunity from the Terror himself. But in fact we only learn of his elevated position from an entry in the local Archives which reports his arrest.[47] As is usual in the case of such entries no indication is given of the reasons for the arrest. These must be sought for elsewhere, first in the account of Cousin.[48] According to this account it must be supposed that even after relations between Fourier and Ichon had been smoothed over by the combined intervention of the Popular Society, the revolutionary committee, and the *conventionel* Nicolas Maure, Fourier continued to smart from a feeling of injustice at the decree of the Convention—which is not surprising when it is remembered that this decree declared him unfit to hold 'similar commissions' in the future (that is similar to the one he had held in Loiret), and thus evidently considerably reduced his possible range of usefulness at a time when he presumably burned to make himself useful to the Republic 'one and indivisible' of which he had recently been a national agent. And so he visited Paris to plead his own case, was presented to the Jacobin Society—possibly with a letter of introduction from Maure who was an active member of the society—and introduced to Robespierre.[49] But he evidently made a bad impression on the latter, for soon after his return to Auxerre he was imprisoned by order of the Committee of Public Safety. Every 'decent' person in Auxerre then interceded in his favour and he was released, only to be re-arrested eight days later. So great was the esteem enjoyed by Fourier at Auxerre that an official deputation was then sent to Paris to demand his release.[50] Saint-Just received the deputation with great hautiness. He admitted Fourier's talents and did not even deplore his sentiments; but he reproached him with lukewarmness: 'yes,' he said, 'he speaks well,[51] but we no longer have any need of musical patriots' and in fact he (Saint-Just) was preparing to act when 9 Thermidor intervened and delivered France and Fourier.

The departmental archives partly confirm, sometimes expand, and nowhere directly contradict Cousin's account. Fourier was arrested for the first time on 4 July 1794 by order of the Committee of General Security dated 1 Messidor (19 June 1794).[52] He was subsequently freed by order of the Committee of Public Safety and then re-arrested on 29 Messidor (17 July) on a further order of the Committee of Public Safety dated 23 Messidor (11 July).[53] As for the deputation sent to Paris to intercede for Fourier before the Committee of Public Safety, this is referred to in a report in the departmental archives[54] where the members concerned describe how Fourier was first released by the Committee as a result of their intercession, only to be re-arrested a few days later.

The reasons for Fourier's arrest are not in doubt: according to the delegation who interceded for him before the Committee of Public Safety

it was the intervention of a certain commissioner Demaillot which led to the order for Fourier's re-arrest. Demaillot reminded the Committee of Barère's report to the Convention declaring Fourier unfitted for public office, claimed that Fourier was an *Hébertist*, and was believed by the Committee. Interesting light is thrown on the activities of the agent Demaillot in the following passage in Lefebvre:

> in Germinal (Year II) the leaders of the *sans-culottes* [of Orléans] hawked round the Popular Society and in the sections an address demanding that the little Capet [that is the Dauphin, son of Louis XVI] should be put to death. The day after the fall of the *Hébertists* such an action was calculated to draw lightning. They were denounced to the Committee of Public Safety. Aignan [of Orléans] came to Paris and in company with Laplanche was received by the committee and sent to Robespierre. Leblois [of Orléans] who happened to be present related after 9 Thermidor that Robespierre had bitterly criticized the conduct of the *sans-culottes* of Loiret. He sent Demaillot there, one of the agents of the committee, who up to the eve of 9 Thermidor savagely pursued the terrorists. From 21 Floreal to 20 Messidor a series of orders of the Committee effected the arrests of the terrorists in Orléans, in Beaugency, Pithiviers, Montargis, Château Renard. At Orléans twenty-eight were thus imprisoned and sent to Paris. The Committee of Surveillance of the Council General of Orléans was suppressed and the permanence of the sections abolished . . . At the same time Demaillot obtained the liberation of a certain number of suspects. He even tried to obtain the creation at Orléans of a Popular Commission . . . So the *sans-culottes* who had prematurely seized power in March 1793 were chased out more than 2 months before 9 Thermidor.[55]

Fourier was therefore evidently arrested on the grounds of his support in October 1793 of the *sans-culottes* of Orléans, who by the time of his arrest in Messidor Year II had for some time been regarded by the Committee of Public Safety—or at least by Robespierre and his associates Saint-Just and Couthon—as dangerous terrorists worthy of liquidation. Fourier who had sided with them in October 1793 was by implication an equally dangerous terrorist. Hence the charge of *Hébertism* levelled against him by Demaillot and accepted by the Committee.

Regardless of the justice or otherwise of the charge of *Hébertism* levelled against Fourier—not to speak of the justification of Robespierre's policy of employing terror to suppress terror and usher in the reign of truth and virtue—the fact remains that 29 Messidor, the date of Fourier's re-arrest, was a most uncomfortable time to be in prison in France on a political charge. In reality, it was of course only a few days before 9 Thermidor and the fall of Robespierre and his associates. But Fourier was not to divine this. For him it would simply have been the time of the 'great Terror', when the guillotine devoured its daily batch of victims and heads fell 'like tiles'—to use the picturesque phrase of the public prosecutor

Fouquier-Tinville. Fourier must therefore have been a prey to extreme anxiety at least up to 9 Thermidor. If we are to believe his own account in his letters[56] to Bergoeing and Villetard he also 'suffered every indignity and was even condemned to death'. There is no documentary evidence for this last assertion. He could only have been condemned to death if he had been brought before the Revolutionary Tribunal in Paris as there was no mechanism for this sentence for a political offence in Auxerre itself. But if he had been condemned to death by the Revolutionary Tribunal, then as there was a gap of at most twelve hours between sentence and execution he would certainly have been guillotined. So that it seems that Fourier's assertion must be interpreted in the sense that imprisonment by order of the Committee of Public Safety on 29 Messidor was effectively equivalent to a death sentence. Certainly, if Robespierre's own head had not fallen on 10 Thermidor Fourier could well have been brought before the Revolutionary Tribunal, and in that case he would almost certainly have been guillotined. Happily for Fourier it was not only those in prison at this time who feared for their lives. There were also many outside who went in fear and trembling, especially a small group of ex-terrorists including Fouché, Tallien, and Fréron who had soiled the purity of Robespierre's Revolution by their acts of savage and wanton barbarity, who rightly feared that they were next on the list to be arrested and brought before the Revolutionary Tribunal, and who in desperation had formed a conspiracy to overthrow Robespierre and his associates. In the event it was, of course, the conspirators who won the day, and no doubt Fourier must have breathed a deep though somewhat confused sigh of relief when news of the executions of Robespierre and his associates[57] reached Auxerre. He may even have imagined that he would himself be freed immediately. In the event he had to wait till 24 Thermidor before an order of the Committee of General Security commanding his release reached Auxerre.[58]

After his release Fourier at first seems to have continued to play his part in local politics, being listed as a member of the provisional revolutionary committee on 23 Fructidor (9 September 1794).[59] On 27 Vendémiaire (18 October 1794) a new and presumably definitive committee was elected from which Fourier resigned on 2 Brumaire[60] (23 October 1794) in order to become a teacher in the new system of education in Auxerre, although he did not actually take up his position until the 26 Brumaire (16 November 1794).[61] On 21 Frimaire Year III (11 December 1794) he was nominated to the École Normale.[62] The somewhat peculiar circumstances under which this nomination occurred were related by Fourier himself in a passage in his letter to Villetard:

> In the month of Frimaire last when I was professor of mathematics at the College of Auxerre, and unbeknown to me, the administrators of a neighbouring district nominated me as a pupil to the École Normale. I did not wish to accept without the authorization of the constituted bodies of the commune of Auxerre. I informed the district administration of this nomination, they confirmed it, and in the order addressed to me included a fair testimonial of my civisme and principles.[63]

Was Fourier's nomination by a neighbouring district entirely unsolicited, or had he perhaps discreetly let it be known that he would not be averse to a change of air? In any case it is interesting to view his nomination in the light of a passage from a work of one of his fellow students at the École Normale:

> When the pupils [of the École Normale] gathered together France had only just emerged from beneath the axe of Robespierre. The agents of this tyranny were everywhere regarded with abhorrence: but the fear which they had inspired, joined to a fear of their return to power, retained them some vestige of credit. They profited from this by seizing the opportunity of quitting the scenes of their vexatious acts. Several had themselves named pupils of the École Normale. They carried there with the ignorance proper to them the hate, distrust, and contempt which followed them everywhere. Beside them were men full of wisdom, talents and enlightenment, men whose names were celebrated in all Europe. But the respect with which the latter were clothed could not extend to the former . . .[64]

Fourier would have had few regrets at the prospect of leaving Auxerre. Then as now Paris was the mecca for all aspiring young Frenchmen. Though he was an experienced teacher of many years, and could not expect to derive much benefit from the École Normale in that respect, nevertheless he must have hoped that through attending the school he would at last get in touch with the outstanding French mathematicians of the day, Laplace, Lagrange, and Monge. He may also have had other reasons for wishing to leave Auxerre not unconnected with the so-called post-Thermidorian reaction.[65] In fact some time before his departure he must already have been thoroughly alarmed at the way things were moving in Auxerre. There had been warnings of the impending storm considerably earlier. Thus Balme and he had been 'purged' for a time from the Popular Society though they were later re-admitted.[66] By the time he left Auxerre Fourier must have wanted to forget all about his part in the Revolution. His participation in the government of the Terror would have made him many enemies. As ex-president of the revolutionary committee he was a marked man. Now he might hope, like so many other 'ex-patriots' including his friend Gautherot, to be allowed to lose his revolutionary past in the great wen of the metropolis. In this he was to be sadly disappointed. But for a time any anxiety on that score must have been forgotten in the intoxicating excitement of the opening *séances* of the École Normale in Paris.

Notes

1. See below Letter IX, Appendix, p. 280.
2. The open emergence of an active republican party can be effectively dated from the flight of the King to Varennes (20 June 1971). The next day Paris was plastered with pro-republican posters of which Thomas Paine later claimed the authorship. On 8 July Condorcet went over to the republican camp. On 17 July the riot of the Champ de Mars supplied the necessary martyrs to the republican cause. The next day the anti-republican members of the Jacobin Society marched off the stage of history in a body to form the Society of *Feuillants*. Contrary to their confident expectation it was the Jacobin Society which flourished and the *Feuillants* Society which withered away.
3. This is the story given by Mauger (p. 272). Cousin (p. 4) also mentions the same speech although he does not say it was the occasion of Fourier entering the Popular Society of Auxerre. Challe (2) p. 112 has a rather different story. According to him Fourier's speech before the Popular Society was to gain exemption *himself* from military service, not to encourage others to enlist as stated by Cousin.
4. See below Letter IX, Appendix, p. 281.
5. *Alm. Yon.*, 1793, p. 109.
6. Meaulle, J. N. (1757–1826). Representative of Loire-Inférieure at the Convention where he voted for the death of the King. Was a member of the Committee of General Security and went on various missions in which he was noted for his moderation. He was a member of the Council of 500 and occupied various positions under the Empire. He was banned as a regicide in 1816 and died in exile (*Bio. Gen.*; *Gde. Encycl.*).
7. *Arch. Yon. Série* L, Reg. 490.
8. See below Letter IX, Appendix, p. 281.
9. Idem.
10. Idem.
11. Porée, vol. 6, p. 93.
12. See below Letter IV, n. 3, Appendix, p. 256.
13. According to Maure's letter of 12 Brumaire. See above p. 34.
14. *Arch. Nat.* AF II 151, *Côte* 1221.
15. See below Letter IV, Appendix, p. 255.
16. Lefebvre (2), vol. 2, pp. 97–157.
17. Though revolutionary from its original inception in 1789 the dominant political tone of the society had shifted steadily to the left from constitutional through republican to Montagnard.
18. Goyré-Laplanche, J. L. (1755–1817). Originally a member of the Benedictine order, he was elected to the Convention for Nièvre. In the trial of the King he voted for immediate execution. The letter of 13 October 1793 from the Committee of Public Safety recalling Laplanche from Orléans and instructing him to proceed to Caen to take the place of Robert Lindet—judged too moderate in his putting down of the federalist revolt in Calvados—talked of the necessity for 'striking acts of severity which spare none of those guilty'. The letter was signed by Collot d'Herbois who would have had personal experience of Laplanche's capacity for such acts at the time when Laplanche and he first set about 'revolutionizing' Orléans in the preceding March. According to Kucinski Laplanche was much more severe than d'Herbois, who later, however, was far to outstrip any of Laplanche's acts of severity by his bloody partnership with Fouché in Lyon from 7 November 1793 onwards when over 1500 persons—including the father of the physicist A. M. Ampère—were executed, often in batches, for their supposed part in the insurrection in the town earlier in the year. If we are to believe Kucinski, although Laplanche was essentially loud-mouthed and boastful rather than evil, nevertheless 'he sent to the Revolutionary Tribunal men and women from Orléans who were condemned to death'. He is also said (Cuissard) to have sent many priests to Nantes where they were drowned. After 9 Thermidor, Laplanche—to his credit—remained faithful to the Mountain. He was ordered to be arrested on 22 Thermidor Year III but managed to hide and ultimately benefited from the general amnesty passed at the last *séance* of the Convention on 4 Brumaire. He is said to have lived out his life thereafter close to the Château de Rivande, home of his wife Adélie de Coinces, who, if Cuissard is to be believed, married Laplanche in spite of her loathing for him only to save her parents from the guillotine. Cuissard states that Laplanche was a prey to continual fears for his life and that before his death he made a public retraction of his conduct and did homage to the religion which he had abjured (*Bio. Gen.*; Cuissard; Kucinski).

19. Aignan, E. (1773–1824). The author of several tragedies and of *Extraits des memoires rélatifs à l'histoire de France depuis 1767 à la Revolution* (Paris 1825) written in collaboration with Norrins. Elected to Académie Française in 1824.
20. De Coinces, Delaguelle (1736–1809). Descended from an ancient bourgeois family of the Salogne. He entered law and took up a position in Orléans. He embraced the Revolution and was elected to the Convention where he sat with the Mountain. In the trial of the King he voted for death without stay or appeal to the people. He was a member of the Jacobin Club and was maintained a member at the *séance* of 12 December 1793. His political career ended with the Convention and thereafter he lived in Paris until his death (Kucinski).
21. No trace could be found of the unfortunate Rimbert.
22. The sanctity of property and the right of holding and acquiring wealth continued to be respected, at least in principle, throughout the most violent and radical phases of the French Revolution.
23. See below Letter IX, Appendix, p. 283.
24. *Arch. Nat.* AF II 146B, Doss. 1179, *pièce* 22.
25. *Proc. Verb. Conv. Nat.*, vol. 24, p. 198.
26. Barère, B. (1755–1841). A barrister by profession, he was elected to the States General and later to the National Convention. At first he voted with the Girondins, pouring ridicule on Robespierre on the occasion of Louvet's attack on 5 November 1792. Later by his services he performed the miracle of calming Robespierre's normally inexorable rancour. As president of the Convention in December 1792 he encouraged the trial of the King: 'the tree of liberty', he said, 'will not know how to grow unless it be watered by the blood of Kings'. He voted for the immediate death of the King without stay or appeal to the people. He became a member of the Committee of Public Safety, remaining neutral up to the insurrection of 31 May and the fall of the Gironde, after which all his actions were directed towards living down his past moderation. On 5 September it was Barère who decreed the Terror to be the order of the day. He played a leading part in the judgement of the Queen and demanded the death sentence on the Girondins. Above all he made himself the ingenious flatterer of Robespierre, all the minutes and orders of the

Committee of Public Safety relative to the diffusion and printing of Robespierre's discourses being in his hand. Without any ideas of his own, if he had a subject to treat he would approach in turn other members of the Committee of Public Safety who would later be surprised to find their own ideas issuing from him as from a faithful mirror. But he was a brilliant orator—Burke dubbed him the *Anacreon* of the guillotine—and an equally brilliant drafter of reports and minutes, and played a key role in the working of the dictatorship of Year II.

In the session of 9 Thermidor he was very perplexed to know which side to support, and tradition has it that he had two speeches in his pocket, one for and one against Robespierre. His embarrassment became extreme when from all sides arose the cry: 'Barère to the platform.' Without mentioning Robespierre by name he attacked him at his most vulnerable point by ordering the arrest of the commandant of the National Guard Henriot, and later he submitted the report on the outlawing of Robespierre and his fellow associates. Following the rising of March he was sentenced to be deported in company with Collot d'Herbois and Billaud Varenne. But Barère managed to escape and remained in hiding till the general amnesty of 4 Brumaire. In 1816 he took refuge in Belgium as a regicide, only returning to France after the July revolution. He was elected a deputy in 1832 but the election was declared void on a technical point and he never sat. No doubt the King, Louis Phillipe, did not relish the idea of one of those who had 'betrayed' his father, Phillipe Égalité, sitting in the assembly (*Bio. Gen.*; *Gde. Encycl.*).

27. *Le Moniteur Universel* (*anc. Ed.*) No. 39, 9 Brumaire Year II.
28. We learn of this hurtful detail in Ichon's letter to the National Convention.
29. *Arch. Nat.* AF II 151, *Côte* 121.
30. Idem.
31. Cousin (1), p. 6.
32. *Arch. Nat.* AF II 164, *Côte* 1345.
33. As related in the accounts of both Mauger and Challe.
34. *Arch. Yon. Série* L, MS. 203.
35. *Arch. Nat.* AF II 146B, Doss. 1179, *pièce* 25.
36. The present whereabouts of the letter of the Committee of Public Safety to Ichon is unknown. It would seem to have been available to Kucinski who relates how the Committee 'invited Ichon to return to the bosom of the Convention to enjoy a needed rest'.
37. See Letter V, Appendix, p. 258.
38. 29 March 1794.
39. The words supposedly applied by one of Lavoisier's judges before the revolutionary Tribunal—*La Révolution n'a pas besoin des savants*—may be apocryphal but they certainly applied to Lavoisier himself.
40. See Letter IX, Appendix, p. 282.
41. *Arch. Yon. Série* L, *Reg.* 229.
42. Moiset, p. 16. For a biographical note on Balme see below Letter XII, n.10, Appendix, p. 295.
43. *Arch. Yon. Série* L, *Reg.* 223.
44. Moiset, p. 19.
45. Cousin, p. 6.
46. *Arch. Yon. Série* L, MS. 1420.
47. *Arch. Yon. Série* L, *Reg.* 322.
48. Cousin, p. 6.

49. I can find no trace of Fourier's presentation to the Jacobin Society or of his introduction to Robespierre. Cousin appears to have originated this detail which he probably had from Roux.
50. The sending of such a deputation from Auxerre to Paris, a distance of some 180 kilometres, at the most dangerous period of the great Terror was at one and the same time a measure of the esteem in which Fourier was held in Auxerre—as Cousin himself notes—of the real (and justified) fear for Fourier's life, and of the bravery of the deputation. In Messidor Year II the whole of France was gripped by fear and sensible people took good care not to draw themselves to the attention of the Committee of Public Safety.
51. If Cousin's account can be trusted, Saint-Just would seem to have heard Fourier speak, presumably at the Jacobin Society. Robespierre was notoriously intolerant of any rivals to his oratorical ascendancy, and if Fourier pleaded his case too eloquently either to Robespierre himself or in his presence before the Jacobin Society he might have attracted Robespierre's suspicious jealousy. A good example of the latter's touchiness in this respect is provided by his unsuccessful attempt to have Couthon announce the victories of the Republic to the Convention in place of the too eloquent Barère.
52. n. 47, above.
53. Ibid.
54. *Arch. Yon. Série* L, *Reg.* 637.
55. Lefebvre (2), vol 2, pp. 162–3.
56. Letter VIII, Appendix, p. 276: Letter IX, Appendix, p. 280.
57. In his letter to Villetard (Letter IX, Appendix, p. 283) Fourier mentions that one of the two commissioners responsible for his arrest in Messidor was declared an outlaw on 10 Thermidor.
58. *Arch. Nat.* F^7 4575, quoted in Porée, vol. 2, p. 165.
59. *Arch. Yon. Série* L, *Reg.* 557.
60. Ibid.
61. *Arch. Yon. Série* L, *Reg.* 219.
62. *Arch. Yon. Série* L, *Reg.* 399.
63. Letter IX, Appendix, p. 281.
64. J. B. Biot (4), p. 67. Quoted in Alain, p. 174.
65. This reaction had begun immediately after 9 Thermidor with a spontaneous movement in the Convention to reduce the power of the Committee of Public Safety culminating in a decree of 24 August 1794 which reduced its status to one of equality with all the other committees of the Convention, and required it in future to restrict itself exclusively to foreign affairs and the conduct of the war. Up to this point there can be no doubt that the majority in the Convention had no desire to attack all the remaining members of the 'great' Committee of Public Safety and other Jacobins. But the movement which had begun by a reduction in the power of the Committee of Public Safety could not stop there. The Revolution had gone into reverse, the highwater mark of *sans-culotte* and Jacobin influence was past, and soon there was a general movement to discredit and remove from office former Jacobins of all kinds. For a time the Jacobins in Paris counter-attacked strongly, especially after the expulsion from the Jacobin club of the renegade terrorists Tallien and Fréron, and the mother society in Paris also drew support from other societies in the provinces. But from around September onwards the tide began to flow ever more strongly against the Jacobins. There was a strong revulsion of public feeling against them

at the time of the trial and release of the 132 prisoners from Nantes. This was accentuated still further through the subsequent trial and execution of the terrorists Carrier and Joseph-le-Bon. All this time the power of the shock troops of the right, the so-called *Jeunesse-Dorée*—led by the ex-Jacobin Fréron well schooled in all the tricks of street and other intimidation—was increasing steadily until ultimately they wrested control of the centre of Paris from the Jacobin supporters. A critical stage was reached with the closing of the Jacobin club in November 1794. At the same time the reaction began to spread into the provinces where it took a much uglier turn. Extensive massacres of Jacobins commenced in various places in the South, especially, as in Lyons and Nimes, where repression in the autumn of 1793 following the federalist revolt had been most severe. Although there are indications that the Thermidorian reaction took longer to reach Auxerre than most places, nevertheless by the end of Ventôse Year II the Thermidorians were evidently in full control. By this time Fourier had already left Auxerre, for according to the departmental archives 'In Ventôse Year III [February/March 1795] the college at Auxerre has become completely disorganized by the departure of professors Balme, Fourier . . .' (*Arch. Yon. Série* L, *Reg.* 224^{1}.).

66. *Arch. Yon. Série* L, *Reg.* 559.

3

FOURIER AND THE REVOLUTION: PARIS

1. The Normalien

THE ÉCOLE NORMALE (Year III)[1] was called into being[2] by a decree of the National Convention dated 9 Brumaire Year III (30 October 1794) with a view to increasing the number of elementary school teachers of which there was at that time an acute shortage in France. This decree was then executed with impressive—and as it turned out excessive—dispatch and on 1 Pluviôse (20 January 1795) the school was inaugurated amid great enthusiasm[3] and with all due pomp and ceremony in the grand amphitheatre of the Muséum d'Histoire Naturelle under the presidency of the representatives of the people Lakanal[4] and Deleyre.[5] Fourier was certainly the ablest—and later the most distinguished—of all the pupils who crowded the banks of the grand amphitheatre on that memorable scene. Unlike some of the other pupils he was also assiduous in his subsequent attendance. In an undated letter[6] to Bonard he gives a vivid impression of the early sessions of the school.

> The *École Normale* holds its sessions at the *Jardin-des-Plantes*,[7] in a middling-sized place of circular shape; daylight only enters from above; the pupils who are very numerous, are seated in rows on the tiers of a very high amphitheatre; there is not room for everyone, and every day there are a fair number who find the door closed; if one is obliged to leave during the session, one cannot enter again. Only pupils are admitted, on presentation of their cards to the officer on guard or the sentry. Some exceptions are made, however, in the case of a small number of loyal citizens and of several women. At the back of the room, and within an enclosure separated by a railing, are seated several Parisian scientists and the professors. In front, and on a slightly higher platform are three armchairs for the professors who are to speak and their assistants. Behind them, and on a second, still higher platform, are the two representatives of the people Lakanal and Deleyre, in the uniform of deputies on detached service. The session opens at 11 o'clock when one of the deputies arrives; there is much applause at this moment and when the professor takes his place. The lessons are almost always interrupted and terminated by applause. The pupils keep their hats on, the professor who is speaking is uncovered; three quarters of an hour or an hour later, a second professor takes his place, then a third, and the usher announces that the session is ended. The names of the professors are familiar to the men of letters who attend the sessions and conferences. I have noticed Cousin,[8]

> Lalande,[9] Brisson,[10] the bookseller Panckoucke,[11] several professors of the Lycée. Several are brought in official carriages or with the deputies; the professors never come any other way. Here are some particulars about the professors: these *minutiae* may appear superfluous, but I am writing them because the papers give no account of them.

Doubtless the particulars given by Fourier did *not* appear 'superfluous' to Bonard, and they certainly constitute one of the very few first-hand accounts of the appearances, idiosyncrasies, and lecturing habits of a quite extraordinarily gifted group of men including the leading contemporary Parisian mathematicians and scientists of the day. *Qua* mathematician, Fourier was inevitably particularly moved and impressed to see before him Lagrange,[12] 'the first among European men of science'. The majority of students, innocents at least as regards mathematics, gave Lagrange 'a rather poor reception'. For them, no doubt, he was just a comic old boy incapable of preserving order, who showed his Italian birth by pronouncing s like z: but for Fourier he was the author of the *Mécanique Analytique*, the creater with Euler of the Calculus of Variations, an analyst of genius, and the fact that there was in his speech 'the hesitation and simplicity of a child' would only have made his true greatness more apparent to Fourier's discerning eye. Laplace,[13] who unlike Lagrange, was only *among* the first rank of men of science, evidently made much less of an impression on Fourier, and he may already have taken a personal dislike to a man whose excessive—and quite unnecessary—deference to authority had recently led him to pocket his pride by accepting nomination as a *pupil* at the École Normale as a result of an 'administrative error' later 'repaired' by the government. As a teacher of long standing himself, and former Professor of Eloquence in Auxerre, Fourier judged the professors' success or failure to communicate with a practised and critical eye. Thus he found that Haüy[14] spoke with extreme precision and clarity: 'it would be impossible to express oneself better'. But he was unable to cope with questions, becoming confused and answering 'badly or not at all'. D'Aubenton,[15] a 'broken old man' who was almost carried to his chair, spoke and read alternately and was understood by no-one. And yet the touch of humour in his speech was sufficient to inspire the respect of the students. Berthollet,[16] 'the greatest chemist we have either in France or abroad', found it excessively difficult either to speak or to perform experiments, and was understood only by those 'who study much or understand already'. Monge,[17] on the other hand, who had a loud voice, and was 'active, ingenious, and very learned', fell into the opposite extreme of excessive clarity: 'One finds even that he is too clear, or rather that his method is not sufficiently rapid.' Of the representatives on the Arts side, La Harpe,[18] with his 'bantering and decisive way of speaking', was of all the professors the one that Fourier liked best to listen to, and after him Garat.[19] Volney,[20] who spoke slowly and seemed to take a pleasure in it, and who astonished the audience by the 'glitter of his diction' evidently tried to stuff too much philosophy into his course which lost its principal object in the process. Of the accounts of the various professors the most vivid and amusing is that of the teacher of deaf-mutes, Sicard:[21]

> Sicard is well known as a teacher of deaf-mutes. Of short stature, still young, he has a strong voice, distinct and vibrant. He is ingenious, interesting, active, and knows how to keep the attention of a large audience. He pleases the crowd who bring down the roof in applause. He praises his subject, his method and his principles, and at every turn talks of the natural man, whom he claims to be deaf and dumb. He is a man of great wit, without genius, who seems to be very sensitive and, is I think, in reality modest, but he has been beguiled by some sort of grammatical system which he claims to be the clue to the sciences. He often speaks for a long time and pompously, and there is something capricious in his accent and diction. His theory of grammar, which is brilliant in certain respects, is one of the craziest I know of. In spite of this there is talk of adopting it, and even prescribing it in all the schools of the Republic. If this comes about we shall have something to laugh at. Apart from this, Sicard is full of enthusiasm and patience and is a paragon of all the virtues, but he is mad: that makes me think that he pleases the ladies, although he is small and rather ugly.

Inaugurated on 1 Nivôse the École Normale was officially closed on 30 Floreal following, though most of the pupils had probably departed for their several homes sometime earlier as on 5 Floreal only forty-nine had voted to continue the courses. No doubt Fourier was among the faithful forty-nine,[22] more especially as he had previously been appointed one of the *maîtres des conférences* in mathematics.[23] For the majority of the pupils the École Normale had been largely a waste of time. Many in fact were quite incapable of following the courses offered and soon found more entertaining ways of passing their time at public expense in a Paris which was reacting furiously from a regime of terror, virtue, and fixed prices in a whirl of gaiety, dissipation, and inflation. Fourier was an outstanding exception. The École had provided him with the opportunity of meeting some of the foremost French mathematicians of the day including Lagrange, Laplace, and Monge. This was the turning point in his career, and provided in retrospect one of the few justifications for adding fuel to the inflationary fire to the tune of some 2½ million francs of public money.[24] Unfortunately Fourier's success at the École Normale was soon clouded by anxiety engendered by rumours of action against him in Auxerre for his part in the government of Year II. By 28 Ventôse (18 March 1795) he was sufficiently alarmed to write to Bonard for information and advice on the matter.[25]

2. Imprisonment of Prairial Year III

Fourier had heard vague news that he had been accused and condemned in the sections and that he had been held up as a peculator and a drunkard, a laughable charge if he had not known the excesses of which the 'armed vengeance of the factions' were capable. What he desperately needed from Bonard were precise details of any charges which had been levelled against him. In fact, in typical Fourier style, he was not so uninformed as he had made out. He had heard that the assembly of the sections had decided to denounce him and demand his exclusion from the École Normale. But he required details of the accusations brought against him. In any case he thought the denunciation irregular and unlikely to succeed. Was he not employed by the Government at the Collège de France? What could harm him except material facts? Where would these facts be found? Who could reproach him with 'an act unauthorized by the law'? His conscience was clear:

> I voluntarily did what I thought was just and useful to the cause which I embraced: what went beyond this I did not impede, but for the most part I could not have done so without rushing to certain ruin.

Of course he could be blamed for not risking his life rather than tolerate injustice, but he demanded at least that he should only be blamed by those who would have done so themselves in his place. Poor Fourier, everything had been going so well at last; his health had been fairly good, Laplace and Lagrange had promised to publish a new proof he had given of the 'famous rule of Descartes', he was 'on very good terms with these two mathematicians', he was devoting himself to study with more enthusiasm than ever, and would have been perfectly happy if only he had been left in peace. But this miserable affair of his denunciation at Auxerre had greatly disturbed him—as he put it to Bonard:

> Whatever it is, mental uneasiness or excessive work, I am not at all well: I have been obliged to keep to my room today.

At the time (28 Ventôse, 18 March 1795) of writing this letter Fourier was evidently a prey to the most gloomy forebodings. These were only too well justified. His enemies in the commune of Auxerre had no intention of leaving him in peace. In an address to the National Convention dated 30 Ventôse (20 March 1795) inveighing against former 'terrorists' the following ominous passage occurred:

> We shudder when we think that the pupils of the École Normale were chosen under the reign of Robespierre and his *protégés*. It is only too true that Balme and Fourier, pupils of the department of Yonne, have long professed the atrocious principles and infernal maxims of the tyrants. Nevertheless they prepare to become teachers of our children. Is it not to vomit their poison in the bosom of innocence . . .?[26]

No doubt Fourier, who always seems to have been singularly well informed, would have heard of this address, and also that of 10 Germinal (30 March 1795)[27] which called for the disarming of terrorists. The insurrection of 12 Germinal[28] would then have done nothing to still his apprehensions, nor the Convention's own decree of 21 Germinal (10 April 1795) for the disarming of terrorists.

However, there is no trace of the address of 30 Ventôse having reached the floor of the Convention, and Fourier would have begun to breath more freely again when the same address was suddenly presented by a commissioner of the commune of Auxerre to the Committee of Public Instruction at their *séance* of the 22 Germinal (11 April 1795).[29] Denunciations of former terrorists were flying thick and fast at the time and the Committee was evidently not prepared to take any action against Fourier and Balme on the basis of so generalized and undocumented a condemnation. They therefore simply sent the address back for comments to Mailhe,[30] at that time representative of the people on mission in Yonne. Given Fourier's special position teaching mathematics in the Collège de France and his relations with Lagrange, Laplace,[31] and Monge it is probable that he would have learnt of what had taken place and once again he would have been thrown into a state of nervous uncertainty. Again nothing happened for a long time. Finally on 26 Floreal (15 May 1795) Mailhe's report on Fourier and Balme found its way back to the Committee.[32] It was not very encouraging. It found Fourier and Balme among the chief of those responsible for the 'tyranny which had recently weighed on the town of Auxerre' and recommended that they be prevented from entering the teaching profession. This could evidently not be ignored, and though the committee may have been loath to take action against such well-qualified persons as Balme and Fourier it nevertheless recommended the Treasury to suspend the indemnities[33] due to them as pupils at the École Normale. At the same time it passed on the report of Mailhe to the Committee of General Security.[34] Two days later, however, as a result of the personal intervention of Maure and Villetard, two of the representatives of Yonne at the Convention, the committee countermanded the suspension of the indemnities of Fourier and Balme.[35] It was the last service Maure would do Fourier. A few weeks later, having been implicated in the Romme conspiracy following the insurrection of 1 and 2 Prairial,[36] and his arrest having been decreed by the Convention, he committed suicide.

As repression grew following the surrender of the Faubourg St. Antoine on 4 Prairial (23 May 1795) Fourier's fears must have grown even sharper. Moreover he now had an additional cause for alarm apart from the original condemnation contained in the address of 30 Ventôse and the unfavourable comments of Mailhe, both presumably irretrievably lodged in the files of the Committee of General Security, for on 23 Floreal (12 May 1795) an order[37] had been issued at Auxerre demanding the disarmament of a number of terrorists including Fourier and Balme. On hearing of this through his relatives, Fourier wrote to the Municipality on 12 Prairial (31 May 1795)[38] pointing out that although he had had no official notification of the order, and no chance to defend himself from the charge of terrorism, nevertheless he would hasten to conform to it. But the day before, unknown to Fourier, Mailhe had issued a second order dated 11 Prairial (30 May 1795)[39] ordering the detention of all those so-called terrorists who had failed to comply with the original order of 23 Floreal. Before hearing of this new order Fourier again wrote to the Municipality asking before which duly constituted authority he should present himself in order to effect his disarmament in a regular manner. Elsewhere[40] Fourier describes how he attempted to disarm the enmity of his opponents in Auxerre by resigning a new position given him at the École Centrale des Travaux Publiques (later École Polytechnique). But even this despairing move was in vain. The reply of the municipality was not long in coming. On the night of 18/19 Prairial (7/8 June 1795)[41] he was awakened by Bayard, chief of the armed guard of the section of Social Contract, and marched off to prison in the Rue des Orties having scarcely been granted the time to dress himself.[42] According to Cousin, who probably had the story from Roux, Fourier never forgot the reply given by Bayard when the *concierge* expressed a hope that Fourier would be back soon—'Come and get him yourself—in two pieces!'[43]

A few days after his arrest Fourier addressed a letter[44] to the chairman of the Committee of General Security in which he gave a detailed account of the events leading up to his arrest, and defended himself vigorously from any possible charge of terrorism. He asked to be interrogated either by Bergoeing himself or in his presence. 'I address my complaints to you confidently,' he said, 'and I beg you to excuse the disorder and length of this letter. I have scarcely enough freedom of mind to justify myself; your humanity will make up for that.'

Fourier's protest, however, with its urgent demand for an interrogation was either unnecessary or immediately effective, for on the same day (24 Prairial) he was freed provisionally by order of the Committee of General Security.[45] But Fourier's provisional liberation was evidently not confirmed as appears from a letter addressed to the Committee of General Security by one of his brothers:

> To the citizen members composing the Committee of General Security.
>
> Citizens, Jean Baptiste Fourier, tailor of Auxerre, at present at Paris for reasons of business, No. 27 Rue David at the house of citizen Moutron, points out that he has just been informed that the citizen Joseph Fourier his brother, former pupil of the École Normale, living at No. 5 Rue de Sauvage Maison de Bourgogne, was arrested there and has been made prisoner in the jail of the Rue des Orties.

> Assured of the innocence of his brother by the principles which he knows to be his, the petitioner is unaware of the reasons for his detention, but he hopes, citizens, that your justice will find itself concerned to order his prompt interrogation. This is why he presents his request to you.[46]

Jean Baptiste's letter was minuted in the margin: 'Fourier demands the liberty of his brother who is arrested. Find the denunciation. Find the papers and the motives and join them to this to make the report.' It was then evidently sent to the committee of the section of Social Contract—where Fourier had resided previously—who returned it to the Committee of General Security with a letter[47] dated 16 Messidor (4 July 1795) in which they detailed their part in Fourier's arrest on the night of 18/19 Prairial. Having been released provisionally Fourier had thus evidently been re-arrested and was still in prison on 16 Messidor almost a month after his original arrest on the night of 18/19 Prairial.

3. The terrorist

It is not known if Fourier was ever brought before a court during his imprisonment in Prairial Year III, or even if he was interrogated. In any case it is evident that the two main charges brought against him would have been his failure to comply with Mailhe's order of 23 Floreal to present himself at Auxerre to be disarmed, and that of having inspired terrorism. As to the first charge, it is evident that his enemies in Auxerre used his failure to present himself there to be disarmed as a pretext for having him arrested in Paris. But what of the far more serious charge of having inspired terrorism in the year 1793–4? Here it is known with certainty what his defence would have been. It is given in considerable detail in a letter to Joseph Villetard written from prison, and in more summary form in the last part of his letter to Bergoeing:

> As to the charge of terrorism, I am unable here to advance all the reasons which will convince you that these charges are unfounded. I shall only insist on the incontestable facts that no-one in the commune of Auxerre was condemned to death or judged by the Revolutionary Tribunal at Paris; that no revolutionary tax was established of any kind whatsoever, that the property of those detained was never confiscated, that no cultivator, artisan, or merchant was arrested, that in what concerns me personally I believe that I introduced into my conduct and my opinions a moderation which I did not find in my adversaries, that far from

having shared the revolutionary madness of many men I regarded it with horror and blamed it publicly; that I have experienced terror more than I inspired it, as I was the victim of it precisely on the same date a year ago, that I was arrested and even condemned to death, delivered by the unanimous demands of the assembled sections, the same which abandoned me or pursued me today, arrested again so that I owed to 9 Thermidor both life and liberty, so that there is no one of my compatriots who has known more danger than I.[48]

Fourier's experience as an advocate before the popular Tribunals in Auxerre and elsewhere had evidently given him useful practice in preparing a case. He wisely confined himself to important matters of fact which Bergoeing, as the then chairman of the Committee of General Security, the body responsible for all police matters throughout France, would have been in an unrivalled position to check. It can be assumed therefore that during the Terror no-one in the commune of Auxerre was executed, or brought before the Revolutionary Tribunal, that no revolutionary taxes were levied and no goods of detainees confiscated. In other words that there were no *major* acts of terror in the commune of Auxerre during the period 1793 to 9 Thermidor 1794.

But if Fourier could thus exonerate himself from any major acts of terrorism, what of his part in the regime of the Terror, especially the arrest and detention of suspects, in the commune of Auxerre? To this charge he would no doubt have replied in the regular manner of all subordinates of a dictatorship before and since:

> Let them take it as certain that I have done nothing arbitrarily and nothing that does not emanate directly from a law[49]

or

> I was entrusted by their own votes with a surveillance determined by the law. I received this position without soliciting it, I continued it without the power of withdrawing from it, and I exercised it without passion.[50]

Fourier was certainly not a Fouché or a Joseph-le-Bon. Having continued, or, as he argued in his letter to Villetard, having been forced to continue a member of the Committee of Surveillance after the Law of Suspects of 17 September 1793 had transformed it into a revolutionary committee and the primary agent of the apparatus of the revolutionary and terrorist government in the neighbourhood, he was more aware than most of his colleagues of the possibility of a day of reckoning. 'I respected', he says in his letter to Villetard, 'the power which had been given me, and repeated a thousand times that we should render an account of it one day.'

But Fourier in office was not only careful to act in perfect conformity with the law, he also—if his own account is to be believed—did everything he could to temper the rigour of that law. Thus in regard to the interior regime in the local detention centre he argued 'that everything not expressly forbidden by the law should be allowed'.[51] He also claimed to have argued constantly against those who were in favour of confiscating the goods of detainees. Nor did he confine himself to negative actions. According to his letter to Bonard of 28 Ventôse Year III there were 'several persons' who were indebted to him for the tranquillity 'which they always enjoyed'. In his letter to Villetard he also refers to certain citizens whom he defended against unjust denunciations, and others whom he protected by secret warning—calling to mind the story of the mission to Tonnerre related by Cousin.

The picture of Fourier which emerges from all these accounts is far from the 'monster of immorality and inhumanity' conjured up by his opponents in the commune of Auxerre. Nevertheless a doubt evidently remained even in Fourier's own mind as appears from a passage in his letter of 28 Ventôse Year III to Bonard.

> However, my opponents can leave it to my conscience, and I am judged by it much more rigorously than they themselves would judge. Let them take it as certain that I have done nothing arbitrarily and nothing that does not emanate directly from a law. That is enough for me to feel no anxiety under a good government. But it is perhaps not enough to satisfy myself, and so I can add that my heart was never party to the evil produced by circumstances. I voluntarily did what I thought was just and useful to the cause which I had embraced: what went beyond this I did not impede, but for the most part I could not have done so without rushing to certain ruin. It will be said that I should have taken the risk rather than tolerate injustice and act as its instrument; that may be true, but at least let me be blamed only by those who would have done so themselves in my place.[52]

Fourier's defence will readily be accepted, especially when account is taken of the measures he took to save the innocent, the feeble, and those who had fallen into 'error'. But those who suffered the indignity of detention on the strength of warrants signed by Fourier were inevitably not disposed to forgive him so easily. As he put it in his letter to Villetard:

> There remain, therefore, those citizens who being noble or priests or relations of *émigrés* found themselves included under the law of 17 September and who experienced a temporary detention when they showed themselves declared enemies of the Revolution. They accuse me of not having been opposed to their arrest and will never pardon me for having signed the warrants for their arrests. They pretend to believe that I could have released them and wanted me to make this use of the trust which had been placed in me.[53]

As it turned out, Fourier was the only member of the former revolutionary committee whom they could reach. The others listed as terrorists were disarmed in conformity with Mailhe's order of 23 Floreal. Fourier alone, either for the reasons given in his letter to Bergoeing, or because he feared to return to Auxerre, failed to comply with the order of Mailhe. His adversaries in Auxerre evidently seized on this exultantly, and pursued him with implacable hatred and 'boundless revolutionary fury' until they had effected his arrest.

If Fourier, therefore, was evidently not a terrorist in the true sense of the word, it still remains to place him in the rather broad political spectrum of the 'patriots' of Year II stretching from *enragés* such as Varlet and Roux on the lunatic fringe of the left, through the *Hébertists*, the followers of Marat and the Robespierrists to the *Dantonists* and *Indulgents* on the right. Now it is certain that Fourier was arrested in Messidor Year II (July 1794) on the grounds of his intervention on the side of the *sans-culottes* of Orléans in the previous October.[54] By July 1794 these same *sans-culottes* had come to be regarded by the Committee of Public Safety—or at least by Robespierre and his associates—as dangerous terrorists worthy of liquidation. Fourier who had sided with them in October 1793 was by implication an equally dangerous terrorist. Hence the charge of *Hébertism* levelled against him by the agent Demaillot and accepted by the Committee. This charge, however, need not be accepted at its face value. No doubt the *sans-culottes* whom Fourier had supported in Orléans in October 1793 were very extreme. What is known of Taboureau makes it probable that at the very least they were *Hébertists*, and their action in calling for the death of the Dauphin the following spring confirms it. But this, of course, by no means proves that the Fourier of October 1793 was himself an equally extreme revolutionary. It is in fact impossible to believe that in October 1793 (or at any other time) Fourier was a committed follower of Hébert with his bloodthirsty appeals in the *Père Duchesne* for so many noble heads (including that of Bailly), just as it is impossible to believe that he would not have been revolted by the call of the *sans-culottes* of Orléans for the death of the Dauphin in the spring of 1794.[55] Nevertheless, while he might even have shared some of Laplanche's personal dislike for the *sans-culottes* leaders, he could still have sympathized with their pitiful plight, and have been moved to intervene on their behalf against Laplanche out of a feeling of natural justice 'in conformity with the principles of the Revolution'.[56] In any case, it is clear that although Fourier's political convictions of October 1793 must inevitably have lacked the bloodthirsty frenzy of Hébert and the *enragés* they were still very radical. This conclusion does not seem as surprising as it might otherwise appear in the light of what is known of the post-revolutionary Fourier, when account is taken of what is known of Fourier's political intimates in Auxerre. If some, like Balme[57] and Bonard[58] were comparatively moderate, no more than republican (though both serving on the revolutionary committee), others including Milon,[59] Gautherot,[60] Maure,[61] and Defrance[62] were much more radical. Thus Milon, who is said to have been a relation of Fourier, and who was one of the principal signatories of the savage address[63] of the Popular Society of Auxerre calling for the trial—and by implication—death of the King, was undoubtedly a *sans-culotte*, that is, more radical than the average member of the patriot or *Montagnard* party. Gautherot, who was also a signatory of this address, was probably even more extreme than Milon. It will be recalled,[64] for example, that there was a strong suspicion that he had played some part in fomenting the riot in Auxerre on 19 August 1792 in which two innocent men were murdered. As for Defrance and Maure, they would seem to have been more radical than republicans like Balme and Bonard but less radical than real *sans-culottes* such as Milon and Gautherot. On the whole it seems most probable that Fourier was closest to Defrance and Maure, and that he was like them a committed *Montagnard*. When account is taken of his presidency of the revolutionary committee in Messidor Year II there is therefore no reason to be surprised at the action taken against him by his Thermidorian opponents in the commune of Auxerre in the spring of 1795.

4. The Polytechnicien

The reasons for Fourier's final release from prison are not known. According to Cousin[65] it was due to the intervention of his pupils in the École Centrale des Travaux Publiques, but if it was due to any intervention this is more likely to have been that of Laplace, Lagrange, or Monge especially the latter two who must by this time have been well aware of Fourier's talents as a mathematician, and, what was even more important, as a teacher of mathematics. Alternatively, and more probably, his release may simply have been due to the changing political climate in the Convention, which after the end of the repression following the Jacobin insurrection of 1 and 2 Prairial veered to the left again in face of a royalist threat which mounted steadily before it was finally crushed on 13 Vendémiaire by Napoleon's 'whiff of grape-shot'. As Fourier (and Balme) were 're-armed' in Fructidor Year III[66] by an order of the Committee of General Security of the eleventh of the same month, it may be assumed that Fourier was released by the former date at the latest. No doubt he then went straight back to teaching in the École Centrale, and when he next writes to Bonard it is from the École Polytechnique, the same school under the new, and now familiar, name it had acquired by a decree of 1 September 1795.

The decree establishing the school had been laid before the Convention by Fourcroy on 24 September 1794 and adopted four days later. Due to various delays—occasioned in part by a particularly severe winter which reduced many of the pupils to a state of near starvation—the school did not open until 21 December. In September 1795, at the end of the first year of studies, it was deemed to have passed its probationary period satisfactorily and was confirmed in its establishment. By a law of 1 September its name was changed from the 'École Centrale des Travaux Publiques' to 'École Polytechnique'. By a succeeding law of 22 October the status of the school as the sole preparatory school for all the so-called schools of application was likewise confirmed. By that time Fourier had found a very congenial niche for himself as teacher and administrator. In a letter to Bonard[67]—who had been appointed one of the provincial examiners for intending entrants to the École—he describes the method of choosing successful candidates by a jury of 'several distinguished scholars' on the basis of marks by examiners from all over the country. A measure of Fourier's standing in the school is given by the fact that if there were to be a further examination of intending pupils on reaching Paris he thinks that he would probably be the one chosen to do it. As for Fourier himself, what he most looked for in entrance candidates was that they should have 'outstanding talents regardless of how much they have actually been taught'—an opinion remarkably similar to one expressed by Monge at the time of the setting up of the school. What was necessary above all was a 'marked taste for mathematics and extraordinary aptitudes together with an aversion, or at least indifference to, the frivolities of which Paris offers so many opportunities'. Whatever the state of Fourier's religious convictions at this stage, he had evidently not lost his serious, Jansenist attitude to life, with its emphasis on the importance of devoting one's energies to study and self-improvement.

Throughout the letter Fourier adopts a tone of new-found importance and weighty judgment which could have been a little galling to his old teacher who is begged 'not to neglect this correspondence' nor to doubt the pleasure it gave Fourier. So that even if Fourier's star was in the ascendent he was full of good intentions to keep in contact with his old friends. In closing he especially asks to be remembered not only to Mme Bonard but also to 'little René' whom he had baptized, presumably in his quality as Abbé rather than in his more recent role as president of the revolutionary committee of Auxerre. All in all there is a strong impression that the scars of the Terror were being forgotten and that Fourier was at last settling down to his true vocation of teaching mathematics.

The years 1795–8 spent by Fourier at the École Polytechnique were marked by periodic crises as the political pendulum continued to oscillate violently from left to right and back again. These crises sometimes left their mark on the École. Thus after 18 Fructidor Year V (4 September 1797) when the pendulum swung to the extreme left and a large number of right-wing members of the Council of Five Hundred were proscribed, the administration of the school thought it prudent to give a mark of their republican sympathies—those of the pupils being somewhat suspect at the time—by planting a tree of liberty. Fourcy has preserved an amusing account of the ceremony at which Fourier himself participated:

> The Minister of the Interior, who had been invited to this ceremony, was represented by the Director General of Public Education. An attempt was also made to have Bonaparte (who was then at Paris) present: he promised, but did not come. As a result Desaix and several other distinguished officers including the generals Andréossy of the artillery, and Caffarelli-Dufulga of the engineers, were all the more conspicuous. After a ceremonial gathering in which Monge as director and after him Fourrier [*sic*], Neveu, and Chaussier, made speeches about the branches of teaching for which they were responsible, the whole assembly moved into the courtyard of the laboratories where an Athenian poplar had just been planted. The director (Monge) attached a tricolour to the tree and in the roots was implanted an hermetically sealed bottle containing an account of the inauguration, together with details of the size of the tree and the various names given to it by Linneaus, Jussieu, Weston, Ayton, Lamarck, and the *Jardin des Plantes*. Verses were sung, strophes recited full of warmth and enthusiasm; in sum nothing was omitted which could stir the heart. A shower unfortunately intervened, and the republican fervour of the pupils did not prevent them from immediately dispersing to seek shelter in the classrooms from whence they watched the remainder of the ceremony through the windows. The incident undoubtedly detracted from the effect which it was hoped to produce on the external world, and produced in the Director General of Public Education a displeasure which he made no attempt to hide.[68]

The school was also affected by the Directory's changing policy towards it which was in turn largely determined by the ups and downs of the financial position of the nation. Thus in a letter[69] of 20 Brumaire Year VI (10 November 1797) to Bonard, Fourier relates how the number of candidates admitted to the school was to be 'greatly reduced by the government' just at a time when not only the number of candidates for entry had increased, but also their quality, a fact which the examiners were pleased to attribute in part to the 'spreading abroad' of Fourier's lectures. One thing which had not changed was the rigid impartiality of the methods of choosing candidates. Thus when Villetard, like Fourier a native of Auxerre, asked Fourier's advice about a young man of the district of Avallon who wished to enter the school he got the following rather dusty answer:

> I replied that there was only one door by which to enter this school, and that it

was neither his business nor mine to introduce the young man there other than by way of examination.

Nevertheless Fourier was not above giving members of the election jury 'advance notice of the candidates they will receive from Auxerre' and was happy to inform Bonard that 'Laplace in particular, whose opinion carries most weight, agrees with me that special attention should be paid to those candidates (that is the ones from Auxerre) since their recommendations originate from a just and very learned man'—Bonard. The same letter mentions 'a young pupil of citizen Billy, Professor at Fontainebleau'. This was S. D. Poisson[70] who was to be successively Fourier's pupil at the École, his deputy as Professor of Analysis during his absence in Egypt, the protégé of Laplace, and finally Fourier's bitter opponent over some questions in connection with the analytical theory of heat.

There is no trace of Fourier having submitted any memoirs to the Académie des Sciences during his years at the École Polytechnique, and apart from one paper in the *Cahiers* of the École there is no indication of his having commenced or continued any major mathematical researches. It must be concluded, therefore, that apart from any administrative duties—and knowing Fourier it is difficult to believe that he could have kept out of either administration or college politics during the years 1795–8—he was devoting most of his energies to the preparation and delivery of his lectures. Two sets of lecture notes have been preserved[71] and display the sort of elegance and clarity of thought one would expect from Fourier, together with a lively interest on occasion in the history of the topic under consideration. Given Fourier's eloquence it may be imagined that these lectures were of outstanding interest and charm and very influential. By 1798 he must have been firmly settled in the chair of analysis and mechanics in which he had succeeded Lagrange in 1797. At this stage he would surely have begun to turn his attention again to his own private research in mathematics which had been interrupted some nine years previously by the Revolution. But once again, as in 1793, his career was to take a new and unexpected turn, this time as a result of a letter received from the Minister of the Interior:

> The Minister of the Interior to Citizen Fourier Professor at the École Polytechnique.
>
> Citizen, the executive directory having in the present circumstances a particular need of your talents and of your zeal has just disposed of you for the sake of public service. You should prepare yourself and be ready to depart at the first order. If you are actually charged with any employment or if you occupy any place at the expense of the Republic you will conserve them during your mission and the salary attached to them will be paid to your family.[72]

Notes

1. This addition is necessary if the short-lived school of Year III is not to be confused with the present École Normale going back with certain interruptions to 1808. The inscription referring to the school of Year III on the front of the present École Normale would seem to imply a connection between the two schools. But as Alain (Chapter 5) conclusively shows, the two schools were entirely distinct as regards both origin and purpose. For the École Normale (Year III) was set up by the Convention to train teachers for primary education, while the forerunner of the present École Normale was set up some sixteen years later as an integral—though rather minor part—of the Napoleonic system of education to train professors for secondary and higher education.
2. The idea of such a school, like so much else in revolutionary and post-revolutionary France, as de Tocqueville was the first to realize, went back to the *ancien-régime*. Following the expulsion of the Jesuit order from France in 1762 the college of Lisieux was transferred to the college of Louis le Grand with the intention of providing an education 'capable of supplying professors to the University of Paris, masters for the residential colleges and teachers for the children of citizens'. In the following year all the 'little colleges' of the University were united to Louis le Grand to form 'an abundant nursery of masters, of which the state has need, and which will spread emulation throughout the land'. The status of Louis le Grand as predominately a training college for teachers of all sorts was strengthened in 1766 by the institution of three degrees (aggregations) in grammar, rhetoric, and philosophy, and by the provision of scholarships for those wishing to prepare for such degrees. Thus some twenty years before the institution of the École Normale (Year III) we find not only the idea but also the creation of such a school, something which no doubt contributed to the excellence of much of the pre-revolutionary educational system. What was in fact new in 1794 compared with 1766 was not the idea of an École Normale, but the grave shortage of teachers of all kinds, especially of elementary school teachers (*instituteurs*) following the destruction of a great part of the old system of education by the Revolution and the failure to replace it by anything new.

   The seriousness of the actual situation was frankly expressed by Barère in a report to the Convention on 13 Prairial Year II. In spite of all attempts to open primary schools, to introduce different grades of instruction, to revive science and literature, to encourage the arts and to train up the younger generation as good republicans, nothing had yet been done, and as a result the Republic was menaced in both her civilian and military functions. In order to combat this situation the Committee of Public Safety considered that a school should be set up in Paris to train teachers to be sent out into all parts of the country. Barère ended by promising a further report on the subject from the Committee of Public Safety.

   The promised report, however, was somewhat slow in coming, which was not surprising considering the ever increasing tempo of the Terror and the growing split in the Committee of Public Safety from 22 Prairial onwards between Robespierre and his supporters and the other members of the committee. In the event it was only after 9 Thermidor that the question of an École Normale was again raised in the Convention, this time by Robert Lindet in his famous state of the nation speech of 20 September 1794 in the brief calm between 9 Thermidor and the full violence of the thermidorian reaction which was soon to sweep away all the remaining members of the 'great committee' including Lindet himself. Referring to education as the surest way of dissipating ignorance and attaching the people to the Revolution Lindet continued:

> Why should you not order that there be opened in Paris a course of studies to form teachers and that a certain number of citizens from all districts capable of fulfilling such [teaching] functions should come to Paris to follow this course?

The Convention embraced this idea with its customary gallic enthusiasm and decreed that its Committee of Public Instruction should present a project for 'Écoles Normales' within twenty days! On 3 Brumaire Lakanal accordingly laid before the Convention a plan for the setting up of Écoles Normales aimed at teaching, not the individual sciences or arts, but the art of teaching itself, first at Paris by means of the foremost savants of the day, then by means of the pupils thus taught throughout France (*Gde. Encycl.*; Alain; Barnard; Dupuy; Fayet).

3. A vivid account of the opening *séance* has been preserved:

> the *séance* was begun by the reading of the decrees of the National Convention for the establishment of the Écoles Normales. At the announcement of this law all the pupils and spectators raised their hats and rose spontaneously to listen respectfully . . . The citizens Laplace, Haüy, and Monge occupied the chair in turn. Having read out their programmes they gave their first lessons. They were listened to in the deepest silence and on several occasions ware warmly applauded.

(*Séances des Écoles Normales*, t. 1, p. VI–VII).

4. See below Letter VI, n. 2, Appendix, p. 262.
5. See below Letter VI, n. 3, Appendix, p. 263.
6. See below Letter VI, Appendix, p. 259.
7. Founded in 1635, the *Jardin des Plantes* had at first been a centre for the culture and study of medicinal plants. With the appointment of Buffon as Director in 1739 the field of study was gradually extended to the whole of botany. The *Jardin des Plantes* was reorganized by the Convention's law of 10 June 1793 and had had its name changed officially to *Muséum d'Histoire Naturelle* under which name it had been opened to the public on 7 September 1794. But the old name lingered on.
8. See below Letter VI, n. 4, Appendix, p. 263.
9. See below Letter VI, n. 5, Appendix, p. 263.
10. See below Letter VI, n. 6, Appendix, p. 263.
11. See below Letter VI, n. 7, Appendix, p. 264.
12. See below Letter I, n. 12, Appendix, p. 247.
13. See below Letter VI, n. 10, Appendix, p. 264.
14. See below Letter VI, n. 12, Appendix, p. 265.
15. See below Letter VI, n. 14, Appendix, p. 266.
16. See below Letter VI, n. 15, Appendix, p. 266.
17. See below Letter III, n. 3, Appendix, p. 253.
18. See below Letter VI, n. 19, Appendix, p. 267.
19. See below Letter VI, n. 26, Appendix, p. 268.
20. See below Letter VI, n. 20, Appendix, p. 267.
21. See below Letter VI, n. 22, Appendix, p. 268.
22. Allain, p. 194.
23. Guillaume, vol. 5, p. 478.

24. There was one other possible justification for the École Normale. It provided almost the first example in France of an educational establishment under government auspices in which lectures were given by the foremost scientists and mathematicians of the day. Formerly there had been an almost complete divorce between science and the universities. In this sense the École Normale of Year III can be regarded as a curtain raiser to the Paris Faculty of Science of the Napoleonic University.
25. See below Letter VII, Appendix, p. 270.
26. *Arch. Nat.* F^7 4439.
27. Ibid.
28. The insurrection of 12 Germinal (1 April 1795) was precipitated by an acute shortage of bread which began to be felt in January and reached near famine proportions by the end of March. The demonstrators marched on the Convention where they broke in and demanded bread. Once the demonstrators had been dispersed the insurrection was put down ruthlessly. Paris was put in a state of siege and the armed forces placed under the command of General Pichegru. Local leaders were arrested together with twelve deputies including the anti-Robespierrists Leonard Bourdon, Amar, and Cambon, and the three 'terrorists' of the old 'great' Committee of Public Safety, Barère, Billaud-Varennes and Collot d' Herbois who were sentenced to deportation.
29. Guillaume, vol. 6, p. 71.
30. See below Letter VIII, n. 2, Appendix, p. 278.
31. Laplace was a member of the Committee of Public Instruction.
32. Guillaume, vol. 6, pp. 203–4.
33. This could have referred to subsistence paid to pupils of the École Normale during their stay in Paris (*indemnité de séjour*), or to travelling expenses to and from Paris (*indemnité de route*) or possibly to the salary paid to each of the *maîtres des conférences* in mathematics.
34. The Committee of General Security was responsible for all internal security and police matters throughout France.
35. Guillaume, vol. 6, p. 204.
36. On 1 Prairial the tocsin rang in the Faubourg Saint Antoine and the *Jardin des Plantes*. This time the women led the march on the Convention, and the cry was bread or death. The demonstrators entered the Convention in sufficient numbers and with sufficient arms to encourage the small remnant of the Mountain to voice their principal demands including the release of Jacobin prisoners. This, the so-called Romme conspiracy, led later to the deaths of six deputies including Romme. Lacking leaders the insurgents were later driven away from the Convention by the loyalist sections. The next day the insurgents marched again on the Convention but returned home lulled by false promises. On 3 Prairial the Faubourg Saint Antoine was surrounded by military forces and on the next day an army under General Menou was about to advance against it when the Faubourg and its starving inhabitants surrendered without a fight. A military commission was then set up to try those implicated in the insurrection. Of 132 persons who appeared before this commission nineteen were condemned to death and committed suicide or were executed including the six deputies of the Mountain referred to previously. These were the so-called martyrs of Prairial, the last of the *Montagnards*.
37. This order is referred to in Letter VIII (to Bergoeing). It would seem to have

been a somewhat tardy local reaction to the Convention's decree of 21 Germinal for the disarming of terrorists.

38. See below Letter VIII, Appendix, p. 276.
39. Ibid.
40. See below Letter IX, Appendix, p. 284.
41. *Arch. Nat.* F^7 4710, Doss. 5.
42. Fourier's house at the time of his arrest, No. 5 Rue de la sauvage peuple de Bourgogne, was not actually in the section of Social Contract. From other documents in the same dossier (F^7 4710) as the letters of Fourier and his brother given below, it appears that when the order of the commune of Auxerre reached the committee of the section of Social Contract they ordered the chief of the armed guard of the section, Bayard, to effect Fourier's arrest. When it appeared that Fourier (possibly as a precaution) had changed his domicile to a residence in another section. Bayard proceeded to the Committee of General Security where he deposited the papers from Auxerre and obtained permission to arrest Fourier at his new residence.
43. Cousin, p. 6.
44. See below Letter VIII, Appendix, p. 276.
45. *Arch. Nat.* F^7 4710, Doss. 5.
46. Ibid.
47. Ibid.
48. See below Letter VIII, Appendix, p. 277.
49. See below Letter VII, Appendix, p. 271.
50. See below Letter IX, Appendix, p. 282.
51. Ibid, p. 282.
52. See below Letter VII, Appendix, p. 271.
53. See below Letter IX, Appendix, p. 282.
54. See above, p. 43.
55. Ibid.
56. See below Letter IV, Appendix, p. 255.
57. See below Letter XII, n. 10, Appendix, p. 295
58. See above Chapter I, n. 24.
59. See below Letter IV n. 4.
60. See above Chapter I, n. 54.
61. See above Chapter I, n. 51.
62. See below Letter XII, n. 9, Appendix, p. 295.
63. See above, p. 16.
64. See above, p. 26.
65. Cousin, p. 6, though he actually uses the later title of the school.
66. *Arch. Yon. Série* L, *Reg.* 324^1.
67. See below Letter X, Appendix, p. 287.
68. Fourcy, pp. 129–30.
69. See below Letter XI, Appendix, p. 289.
70. See below Letter XI, n. 7, Appendix, p. 290.
71. See Grattan-Guinness (3), pp. 5–8, for an interesting brief account of these lectures.
72. Fourier Dossier AN.

4

YEARS OF EXILE: EGYPT AND GRENOBLE

1. Permanent secretary of the Cairo Institute

In writing to Fourier, the Minister of the Interior was obeying the orders he had received in a private and confidential letter from the Directory instructing him to 'put at the disposition of General Bonaparte the engineers, artists, and other subordinates of your ministry together with the different things he will demand of you for the purpose of the expedition to which he has been assigned'.[1]

The letter from the Directory to the Minister of the Interior was dated 26 Ventôse Year II (16 March 1798), and the letter from the Minister of the Interior to Fourier 7 Germinal Year II (27 March 1798). On the following 19 May in company with Bonaparte, his fellow generals and officers, and members of the scientific and literary commission[2] together with 30 000 soldiers and sailors, all stowed into some 180 ships (including thirteen ships of the line), Fourier, in all probability at sea for the first time in his life, found himself being carried away from Toulon bound for some unknown destination. That Egypt was the actual destination of this great armada was a secret which had been somewhat miraculously restricted to a small group of men, and which certainly had not reached the ears of Nelson who remained as ignorant of the true destination of the expedition as he was of its actual position throughout the passage to Egypt.

For a great part of the voyage many members of the expedition including Bonaparte suffered cruelly from sea-sickness. In the days of relative calm the latter was fond of holding his so-called 'institutes' in which he would discuss all manner of questions with members of his staff and of the scientific and literary commission.[3] It was presumably on such occasions that Bonaparte came to know Fourier and to assess his worth and potential gifts as an administrator. As professor at the École Polytechnique Fourier was one of the senior members of the scientific commission, and would have dined at the Captain's tables of his own and other ships.[4] There he would have had a chance of meeting other senior members of the scientific and literary commissions and naval and military officers. In fact we know that he became friendly with General Kléber[5] during the voyage, a circumstance which was later to have unfortunate consequences. The former *conventionel* and ex-terrorist Tallien,[6] one of the leaders in the conspiracy against Robespierre, would have had a special interest for Fourier, who may, however, have been discreet about his own part in the Revolution in the years 1793–4.

Throughout the voyage, Nelson with his squadron of thirteen 74 pounders frantically scoured the Mediterranean for the French armada, coming as close as two miles to it on 22 June. The proximity of the English fleet proved nerve-racking to most members of the French expedition apart from Bonaparte who was too busy preparing for Egypt to bother about the possibility of an encounter with Nelson. Apart from the capture of Malta with its timely contribution of some 7 000 000 gold francs to Bonaparte's war chest following the suppression of the ancient order of the Knights of Malta, the journey was uneventful if full of discomfort and suffering for the lesser ranks owing to their cramped quarters and indifferent rations. On 1 July 1798 Pompey's pillar at Alexandria was at last sighted, and the following day the city was captured after a brief resistance.

Amidst the frenzied preparations for the march on Cairo the members of the commission of arts and science tended to be forgotten. Alexandria turned out to be an uninspiring slum and some members of the commission —including Fourier—were fortunate to be given temporary quarters in the much more pleasant and salubrious town of Rosetta. Here Fourier took up his first administrative position in Egypt as a member of the provincial purchasing commission. In the meantime the main body of the army were pushing on towards Cairo. In their march through the desert they suffered terrible hardships due in part to a lack of proper equipment especially water bottles. On 21 July the Mameluke forces under Murad Bey were routed at the Battle of the Pyramids, and on 24 July Bonaparte entered Cairo. But a few days later these brilliant successes were more than cancelled by the annihilation of the French fleet in Aboukir Bay. Regardless of anything Bonaparte could say the ordinary soldier no doubt shared the feelings of the physicist Malus[7] on learning of this catastrophe:

> From then on we realised that all our communications with Europe were broken. We began to lose hope of ever seeing our native land again.[8]

Equally serious, on learning of the disaster of Aboukir Bay, the Directory ceased to make any sustained or serious attempt to assist Bonaparte or even to communicate with him.

Magnificently undeterred by the destruction of his fleet, Bonaparte set to work to bring some sort of order out of the incredible confusion, poverty, disease, filth, and decay which were the most prominent characteristics of the Cairo scene. Thus he soon set up a municipal 'divan' or council in the hope of persuading the native leaders to run their own affairs, subject, of course, to the ultimate control of the French. The Thermidorian Tallien was appointed French commissioner or observer at the meetings of this body, a position later held by Fourier.

Among a multitude of other tasks Bonaparte still found time to oversee the foundation of the Cairo Institute, a body which had no doubt been much discussed during the passage to Egypt, and which was formally created by an order dated 20 August 1798. Following the procedure at the setting up of the Institut in Paris—a body of which Bonaparte was still at this time inordinately proud to be a member, always signing himself: 'Bonaparte, member of the Institut'—seven foundation members were first agreed on who were then responsible for drawing up a list of further members chosen from the Commission of Arts and Science. There were to be four classes of twelve members each in mathematics, physics, political economy, and literature and the fine arts. Only the mathematics class was ever filled, and it also contained the most distinguished collection of members including Monge,[9] Fourier, Malus, and Bonaparte himself. The best-known members of the other classes were Berthollet,[10] Conté,[11] and Geoffroy Saint Hilaire[12] (Physical class) and J. B. Say[13] (Political Economy). In the section of Literature and Fine Arts was the artist Denon[14] who brought back with him to France a large collection of drawings which provide an invaluable pictorial record of many aspects of the Egyptian expedition.

The first meeting of the Institute took place on 25 August 1798, Monge being elected president, Bonaparte vice-president, and Fourier permanent secretary,[15] a position which he continued to hold throughout the whole period of the French occupation of Egypt. Monge—no doubt aided by Fourier—seems to have played the chief part in the organization and activities of the Cairo Institute from its foundation till his return to France with Bonaparte in August 1799. The Institute was located in the former palace of the Beys, the great room of the harem serving for the *séances*, and the rest of the building was used for lodging the members and for laboratories, workshops, and a museum of Egyptian natural history. The garden of the palace became the botanical garden of the Institute.

Napoleon had envisaged a three-fold purpose for the Institute: the progress and propagation of the sciences in Egypt; the collection and publication of natural, historical and other data on Egypt; last, but not least, the Institute was expected to act on occasion as a sort of think-tank to advise the civil and military administration on any questions with which they might need assistance. Bonaparte—who retained a real interest in the work of the Institute for the remainder of his stay in Egypt—propounded a number of questions[16] at the first meeting of the Institute all stamped with his own severely practical, unphilosophical caste of mind: could the army's baking ovens be improved, and if so how? Was there a way of brewing beer without hops? What methods were in use to purify the Nile water? Which was more practical in Cairo—windmills or watermills? Were there any resources for manufacturing gunpowder?

Although committees were duly set up to study these and other questions, the activities of the Institute's members were not exclusively devoted to such practical matters. Thus natural historians like Geoffroy Saint Hilaire were much more concerned with scientific study of the fauna and flora of Egypt, and although Fourier read a note on a proposed wind-activated watering machine to the Institute on the first complementary[17] day of Year VI, a few days earlier, on 21 Fructidor of the same revolutionary year, he read a memoir on his old love, the general resolution of algebraic equations: and so, as Cousin[18] remarks, on the banks of the Nile Fourier still occupied himself with the problem which had already so greatly exercised him at Auxerre, and Navier (to whom Fourier's papers were entrusted at his death) claimed that certain of Fourier's papers on the subject were written with Egyptian ink on Egyptian papyrus. Unlike Geoffroy Saint Hilaire and other members of the Commission of Arts and Science who sometimes found time hanging heavily on their hands, Fourier seems always to have been fully occupied either on his administrative duties as permanent secretary of the Institute, or in writing papers to be read before that body. Among these Cousin[19] notes four mathematical memoirs.

Sometime in the first half of 1799 Fourier took part in the expedition to Lake Natron under General Andréossy,[20] Berthollet being the other principal civilian member of this expedition besides Fourier. Earlier he had been fortunate to miss the ill-fated Syrian campaign in which French casualties[21] were more than a third of the original number which had set out from Egypt in February 1799. On 14 June Bonaparte made his 'triumphal' re-entry into Cairo with the remnants of his Syrian army. On 25 July following, he annihilated a Turkish invasion force at the battle of Aboukir. He then learnt through newspapers thoughtfully supplied him by the British naval commander, Sir Sidney Smith,[22] of the troubled situation in France. Determined to risk all on a return to France, Bonaparte left Egypt on 18 August accompanied by a small party including the inseparable Monge and Berthollet. Inevitably rumours got about before the actual departure, and at a meeting of the Institute Monge and Berthollet found themselves acutely embarrassed to deny their imminent departure from Egypt. Fourier, in particular, was so agitated at the thought of their leaving him behind that he followed them into the street and could hardly be persuaded to let them go,[23] while the poet Grandmaison[24]—who had served with Fourier on the Rosetta purchasing mission before they were both called to the Institute in Cairo—followed Bonaparte to his port of embarkation, rowed out to the General's frigate, and begged to be taken back to France. Much amused, Bonaparte relented and took him on board.

In spite of pressing military and administrative duties Bonaparte characteristically found time immediately before his return to France to plan an expedition by a mixed scientific and literary commission to Upper Egypt under the joint leadership of Fourier and Costaz.[25] On the return of the expedition Fourier was put in charge of the collation of its discoveries. Later this formed the basis of the *Description of Egypt* for which Fourier supplied an historical introduction which was later to cost him much anxiety and labour while Prefect of Isère.

Before leaving Egypt Bonaparte had left a letter to Kléber nominating him as commander in chief. Kléber, who detested the politician in Bonaparte as much as he admired the general, accepted the position with mingled rage and scorn, for Bonaparte had not been able to bring himself to face Kléber in person before his departure, possibly fearing that Kléber would have refused the position offered him and thus have made it much more difficult for Bonaparte to leave Egypt. Under Kléber Fourier was appointed president of a bureau set up to collect information relating to modern Egypt. Fourier's work in this position and as secretary of the Institute was carried on against a constantly troubled military and civilian background.[26] Thus following the countermanding by the British government of the convention of El-Arish entered into by Kléber and Sir Sidney Smith on 28 January 1800, fighting broke out between the French and Turkish forces. Although the main Turkish forces were routed by Kléber at the Battle of Heliopolis (20 March 1800) nevertheless there was an insurrection in Cairo which began in March and only ended on 22 April when the Turkish forces in the city were evacuated.

On 14 June 1800 the French expedition suffered an irreparable military loss through the assassination of Kléber. It was Fourier who read the funeral oration, a speech 'whose hollow bombast'[27] may have suited the occasion and audience but which does little to enhance Fourier's memory. This speech also contained some rather fulsome flattery of Bonaparte who by this time had established himself in Paris as First Consul. It is to be hoped that Fourier was not obliged to witness the impaling of Kléber's assassin, a proceeding which took place on the route of the funeral procession to the grave of Kléber.

Under Kléber's successor Menou,[28] Fourier was appointed to a number of additional administrative positions including that of French representative on the divan of Cairo—a position which had earlier been filled by the Thermidorian Tallien—chief of the administration of justice in Egypt, and examiner of naval cadets who had passed through the mathematical school at Cairo. Fourier was also entrusted with delicate diplomatic negotiations with Murad Bey, the formidable leader of the Mamelukes who had evaded capture by both Bonaparte and Desaix.[29] His success in persuading the wily Murad to sign an alliance with the French command at a time when they were none too strong militarily represented a not inconsiderable diplomatic achievement.

Following the landing of a British Expeditionary Force under General Abercrombie at Aboukir Bay on 8 March 1801, and the repulse at Canopus (21 March) of a French attempt to drive the British forces back into the sea, the position of the remaining French forces in Egypt deteriorated rapidly. Menou withdrew to Alexandria and was cut off by a flooding of the surrounding country by the British. At this point the members of the Institute felt it was time to go home. As a preparatory move they had themselves transferred from Cairo to Alexandria prior to embarking for France. Understandably, those who were to be left behind did not view the retirement of the savants with any great enthusiasm. Thus General Menou wrote to Fourier as follows:

> Good citizen, I did not indicate any discontent regarding your departure either to the army or to the government . . . but your departure in the actual circumstances appeared to me, and still appears to me, and will always appear to me, immoderate and ill-conceived. But the lively manner in which I have expressed myself on this subject is entirely for your own personal attention.[30]

When the boat with the members of the Institute on board left the port of Alexandria it was immediately arrested by the British Fleet, apparently much to the surprise of its passengers. Following the persuasive arguments of Fourier, the commander of the fleet, Sir Sidney Smith, agreed to release all the members of the Institute apart from Fourier himself whom he retained as a hostage. The other voyagers were very upset by this turn of events, but not nearly as upset as when they discovered that General Menou would not allow them to re-enter the port of Alexandria because of their contact with the enemy! Ultimately, when Menou relented and allowed the members of the Institute to return to Alexandria, Sir Sidney Smith released Fourier while retaining his papers. In the meantime the French position had deteriorated still further. Belliard,[31] the commander of the French forces besieged in Cairo, had capitulated. For a while Menou hung on, but he too was soon forced to surrender and the terms of capitulation were signed on 30 August 1801.

After the capitulation the officer in command of the British forces, General Hutchinson, attempted to commandeer the scientific collections of the French expedition. But when Geoffroy Saint Hilaire threatened to follow them to England Hutchinson changed his mind and allowed the French to keep their collections. He was, however, adamant about the Rosetta stone which Menou was forced to surrender. This stone neatly epitomizes the French expedition to Egypt: its position in the British Museum symbolizes the military failure of the expedition, while the stone itself is a perpetual reminder of the enormous scientific importance of an expedition which laid the foundations of modern Egyptology.

On the passage to Egypt Bonaparte had promised each of his soldiers enough money on their return to France to buy six acres of land. This was to become the subject of ribald comment by the troops in Egypt, and those who were fortunate enough to return to France carried with them little else than an inexhaustible supply of stories of their triumphs and tribulations in Egypt. Fourier was more fortunate than most. *His* war had been at the least a very successful administrative experience which seemed certain to mark him out for some important appointment on his return to France. As to the impression which he had made on his colleagues of the Commission of Arts and Science, little has survived beyond two somewhat contradictory records. The first, a contemporary account, is found in a letter written to Cuvier by Geoffroy Saint Hilaire while waiting in quarantine at Marseilles on his return to France from Egypt: having referred to Fourier as a man 'of great intelligence and merit' he continued:

> we were so close together, and his claims became so overweaning, that we often came in conflict: however there was finally a relationship between us which was sufficiently large, frank, and intimate on my side, perhaps political on his.
>
> His plan since the departure of Berthollet had been to prove by hurtful sarcasms that all his colleagues of the Institute were *ignoramuses*, and that his pupils, who were then civil engineers, were the only ones who had any knowledge. You can imagine that he was strongly supported by the latter and that he mounted a concealed attack which threatened to have some effect until the good people without pretensions took offence at it. Fourier's aim was to have a name for the same superiority and understanding which it is customary to afford in Paris to Lagrange and Laplace.[32]

Another, rather different, impression was given many years later by Jomard in a funeral oration at Fourier's graveside:

> which of us has forgotten his conduct so full of justice and generosity towards the natives? How much his mind, his understanding, and his graciousness gained us followers and contributed to maintaining the authority of a handful of men over a population then so fanatical, and so stirred up by rich, strong, and powerful enemies, and by leaders, religion, and arms. Who would have said that this man of so lofty a mind, so sure a judgement, and so profound a knowledge would have had an exquisite sensibility for the beauties of art? And yet there is none among either his disciples and friends or the companions of his dangers and hardships who does not render homage to the delicacy and purity of his taste. It was the

> same tact, the same wisdom, which then shone in his judgements and conversation as has since in all his works. What a charm he could bring to every subject, what ingenious comparisons, what an inexhaustible memory, what gentle philosophy animated his conversations whether under the silent monuments of the town of a hundred gates or in the sound of the cataracts! To the great memories of the historian are henceforth joined those of a bold enterprise which will always honour France. Fourier hallowed them one and all in a discourse that should not die; all except the part which he himself played in the expedition. But posterity will add his name to those whom his eloquent pen has immortalised.[33]

Discounting somewhat both the evident *animus* of the natural historian for the theoretical physicist, and the nature of the occasion of Jomard's remarks, it may be assumed that the 'permanent' secretary of the Cairo Institute was neither as prejudiced as Geoffroy Saint Hilaire made out, nor such a paragon of all the virtues as presented in Jomard's oration.

Having returned to France Fourier immediately reopened his correspondence with Bonard:[34] the voyage itself from Egypt had left him with 'nothing but the most agreeable memories' though the 'prolonged hardships' during his stay in Egypt had left their mark on his health. The study of the 'antiquities of Egypt' and his many administrative duties had not diverted him from mathematics though he had not yet published any of his researches. But he intended to do so as soon as he had published his work on the 'astronomical monuments' of Upper Egypt, provided he was 'fortunate enough to enjoy a substantial period of leisure in Paris'. After a brief indication of the nature of his work on the 'astronomical monuments' it was the turn of Bonard and his family:

> Present my regards to Madame Bonard and embrace in my name all your charming family. But I retain an altogether special affection for that one of your children whom I baptized. If M. Rosman still lives in Auxerre express to him the token of my regards and unalterable attachment which reflection and age can only increase.

2. The prefect of Isère

On his return to Paris Fourier immediately took up his teaching duties again as Professor of Analysis at the École Polytechnique. But not for long. On 18 Pluviôse Bonaparte wrote to his trusty chemical henchman Berthollet as follows:

> Citizen Senator, the Prefect of the Department of Isère having recently died, I would like to give an earnest of my confidence in citizen Fourier by appointing him to this place. Please be good enough to speak to him about it and let me know if this would answer his expectations.[35]

Berthollet's line of communication with Fourier led through Gaspard Monge to whom Berthollet then wrote as follows:

> My dear friend,
> Please find Citizen Fourier and get him to promise to be at your house this evening between eight and nine o'clock. I have a proposal to make him on behalf of the First Consul about an urgent matter. I embrace you
> Signed Berthollet.[36]

If we are to believe Cousin[37] the First Consul's proposal was in fact a command which Fourier would have ignored at his peril. It is difficult to credit this, since Fourier was firmly established in the École Polytechnique and even Bonaparte would have been unable to have him dismissed from that position simply because he had declined to accept the prefecture of Isère.[38] But Fourier could well have found that after his large administrative responsibilities in Egypt his chair at the École had shrunk somewhat since 1798, and that he may in fact have been looking for a new, and more responsible, position is suggested by Bonaparte's request to be informed if the proposed position answered Fourier's 'expectations'. In that case, if he were to refuse the position offered to him, he might never have been offered another, although he could hardly have been attracted by the position of prefect in a town such as Grenoble so remote from Paris as to amount to virtual exile. Whatever his feelings of disappointment on this score he seems quickly to have stifled them, and a few days later he was appointed Prefect of Isère by an order of the First Consul dated 23 Pluviôse.[39]

Having accepted the position of Prefect of Isère Fourier seems to have been in no hurry to leave Paris to take up his position, for on 12 Germinal we find the minister of the Interior, Chaptal,[40] writing to him at his Paris address as follows:

> The First Consul requests me, citizen Fourier, to inform you that the affairs of the Department of Isère require that you proceed to your residence. Please inform me of the time of your departure and when you have arrived at Grenoble notify me of your installation.[41]

But Fourier had already left Paris, and Chaptal's letter only caught up with him after he had been installed as prefect in Grenoble. From there he replied[42] on 29 Germinal excusing the lateness of his departure from Paris on the grounds of the difficulty of winding up his personal affairs in Paris and Auxerre in less than three months, while assuring the minister of his unreserved devotion to duty and his desire to 'reply to the benevolent and consoling views of the Government so justly honoured throughout Europe'.

The department of Isère to which Fourier had been appointed prefect was one of eighty-three such regions into which France had been divided by a decree of the Constituant Assembly of 3 February 1790. The Assembly had been concerned to cut through the tangled web of the administration of the *ancien régime* based on provinces and replace it by something new, more efficient, and more democratic. Thus each department was headed by an elected assembly with a 'general council' of thirty-six members and a '*procureur syndic*' representing the King. Under the revolutionary government of Year II the assemblies and their general councils, almost entirely composed of well-to-do *Bourgeoisie*, were rightly suspected of Girondin sympathies, and government agents were appointed to watch over them. Under the Directory each department had its own ruling body with an accompanying 'general commissioner' appointed by the central government to supervise its working including the enforcement of laws. Finally, by a law of 28 Pluviôse Year VIII inspired by the First Consul, the departmental directories were abolished and replaced by a single person, the prefect, who was thereafter the sole representative of the executive power in the department. And thus, with the substitution of prefects for intendants and departments for provinces the system of centralization adopted in France after the Revolution was very similar to that which had been in force before it—a striking illustration of de Tocqueville's principle.

Once installed as prefect, Fourier's first care was the administrative machinery of his prefecture. He found the four counsellors already in position not entirely to his liking and had them replaced over a period by others including a certain high-sounding Joseph Marc de Gratet du Bouchage, doubtless a relative of the Du Bouchage who as Minister of Marine under King Louis XVIII was to be such a staunch supporter of Fourier. As his principal private secretary he appointed a certain Auguste Lepasquier, a person with extensive literary training, the local poet laureate, whose commemorative verse extended from a quatrain commemorating the marriage of the Emperor Napoleon with Marie Louise of Austria to an ode to the Count D'Artois, the future King Charles X, on the occasion of his passage through Grenoble in 1814. Lepasquier had particular responsibility for all literary affairs and for education. A second private secretary, Raynaud, looked after other administrative affairs. These were the two key men of Fourier's administration and between them they saw to the execution of all his instructions. As third secretary he chose a certain Professor Alexis Michallet, a stylistic purist intended for the writing of specially important dispatches. But Michallet became too fond of the *vin du pays* and had to be dropped. All Fourier's secretaries and clerks had at least one onerous task in common, the decipherment of his handwriting: abominable at the best of times, except in the most fateful letters such as that written from prison to the Representative of the People Bergoeing, it degenerated in notes and minutes—with which, according to Letonnelier, Fourier was in the habit of covering drafts—into 'a villainous little scrawl'[43] which must have been the despair of his officials.

Fourier's tasks as prefect were exceptionally varied. His first duty as sole representative of the executive power in the department was to see to the promulgation and enforcement of the various laws and directives which flowed in a steady stream from Paris, especially those concerned with taxation and recruitment for the consular and imperial armies. He was also expected to keep the central government constantly informed about the state of the department, especially as regards the morale of its citizens and the preservation of law and order. This he did by a series of reports covering every conceivable subject from the cutting down of trees of liberty[44] and the activities of vandals in the gardens of ex-Ursuline nuns,[45] to the difficulties encountered in recruitment 'principally in the most mountainous part of the department'.[46] Another of Fourier's important early tasks was to effect a reconciliation between the warring parties which were the aftermath of the Revolution. For it was the settled—and in this case wise—policy of Napoleon to unite the maximum number of Frenchmen regardless of their original sympathies, republican, royalist, or ecclesiastical, in support of his policy and person.[47] In the event Fourier seems soon to have succeeded in gaining the support of the more important members of society. From the beginning he was on excellent terms with the nobility whose support for the regime Napoleon prized so highly. If the nobility were first drawn to Fourier by his pleasant old world manners and the charm of his conversation—a former president of the *Parlement* of the Dauphiné said of Fourier that 'he could give lessons in theology to bishops, and in politeness to pre-1790 parlementarians'[48]—they soon had better reasons for supporting him, for he was always ready to do them a service. For example, Cousin[49] tells the story of the *émigré* returning from exile who had the chance to buy back his original property which was being auctioned as a national holding. The property, which was worth much more than the nominal figure put on it, was to be auctioned in public, and there was in reality no hope of the original holder buying it back. In desperation he approached Fourier and won his sympathy. The auction was fixed for 8.00 a.m. on the unwritten, but universal, understanding that bidding was unlikely to commence before about 10.00 a.m. Fourier, however, in his capacity as prefect turned up precisely at 8.00 a.m. when only a handful of interested parties were present including, of course, the former owner. At 8.15 a.m. the prefect instructed the usher to commence the bidding making a great show of anger at the small attendance. In the event the former owner was then able to buy back his ancient property. Doubtless no one was much deceived by Fourier's show of anger, on the other hand there was no public outcry since the *émigré* in question was personally respected and liked by all classes.

Another service rendered the nobility by Fourier was in the matter of the guards of honour.[50] These were to be recruited from the better families of the country. But many of these families had little inclination to provide recruits, having already lost too high a proportion of their members in the Revolution. Fourier therefore arranged that they should buy themselves immunity, the money provided being used to raise a body of paid volunteers. Thus the demands of the central government were met while the nobility retained their sons at home.

Apart from the nobility, the other main class whose support Fourier sought was that of the wealthy middle class made up largely of self-made and mildly republican members of society, the so-called *Bourgeoisie*. Among these he is said to have been popular for himself and also because of his excellent administration devoid of red tape, excessive paper work, and general humbug and tomfoolery of all kinds, for Fourier evidently had the knack—essential to all first-rate administrators—'of doing much without any great stir'.

As for the local clergy, he apparently soon succeeded in establishing good relations with them by his skilful and sympathetic treatment, no doubt assisted by Claude Simon,[51] Bishop of Grenoble, a former tutor of Joseph Bonaparte, and ardent supporter of his brother Napoleon. On 3 July 1803 Fourier visited the Cathedral of Notre Dame in Grenoble to receive the oaths of curés nominated in the diocese.[52] After the ceremony, which was carried out with great pomp and before a considerable assembly including Bishop Simon, mass was celebrated while incense was given to the prefect. Perhaps the fragrance of the incense evoked in Fourier the memory of the last mass he had communicated in the Abbey St. Germain before the rising tide of the Revolution had terminated the life of the Abbey and scattered its remaining handful of inmates including the abbé Fourier.

History does not relate Fourier's relations with members of the extreme Jacobin party in Isère. They were probably of little importance, but we can imagine that it was perhaps with this group that he showed least sympathy. His own Jacobin past was something he probably wished to hide.

Fourier's major achievement as prefect of Isère lay in his decisive contribution to the draining of the swamps of Bourgoin. Covering an area of some twenty million acres these swamps had been useless except for a little rough grazing and had been responsible for annual epidemics of fever which ensured that few of the surrounding inhabitants ever passed their fiftieth birthday. On the advice of Colbert, Louvois, and Vauban the swamps had been ceded by Louis XIV to the Maréchal Turenne on the understanding that he had them drained. A number of attempts were subsequently made to begin the operation of draining. But in spite of the support of the various intendants of the Dauphiné all these attempts broke down over the impossibility of achieving among the forty communes bordering the swamps agreement sufficient to justify the commencement of draining operations. It was Fourier's signal achievement to succeed where his predecessors had failed. After negotiations stretching over a period of some four years, he finally had the satisfaction of seeing the mayors of all the communes subscribe to a common treaty executed at Bourgoin on 7 August 1807. His success was due to a combination of persuasiveness, charm, persistence and endless patience, for he was apparently obliged to visit all the communes in turn and meet most of the inhabitants individually before he could persuade them to give up, at least temporarily, their immemorial rights of pasturage for the sake of the future betterment of the land. Augustin Perier,[53] one of the foremost citizens of Isère during Fourier's prefecture, was particularly well acquainted with the various aspects of the draining of the swamps. When Cousin met him in 1831 he was still full of admiration for Fourier's handling of the negotiations leading to the signing of the 1807 treaty.[54] Once this treaty had been signed it was possible for the draining to begin. The company Bimar responsible for the operation of the draining was well aware of its debt to Fourier for the 'marks of goodwill which made it fitting that the Company should witness its gratitude to him in a special manner'.[55] This it did in a suitably worded flowery address which later proved useful to Fourier when he came to claim a pension on his return to Paris in 1815. Equally grateful, though at a somewhat later date, were the proprietors holding land in the marshes, this time for services rendered to protect them from the 'unjust and constantly renewed pretentions of the company Bimar'![56]

The draining of the swamps was completed in 1812. The cost was 1 200 000 francs, the increased value of the reclaimed land alone without allowing for any later improvements in its condition was of the order of 4 000 000 francs. Even more important, if incapable of precise monetary assessment, was the striking improvement in the health of the inhabitants following the cessation of the annual epidemics of fever. All in all, Fourier seems to have been fully justified when he claimed the draining of the swamps of Bourgoin was the greatest public work which had been completed in France in 'these last years'.[57]

Fourier's other major administrative achievements as Prefect of Isère was the opening up of the French section of the road from Grenoble to Turin via the Lantaret and Mount Geneva. Although the original route was much longer it naturally contributed to the wealth of the countryside through which it ran, and the project for a new route was vigorously opposed not least by the then Minister of the Interior[58]—Fourier's direct superior as Prefect—who was himself a native of the countryside in question. Eventually Fourier had a memoir presented directly to Napoleon by a number of local notables setting forth the advantages of the new route including the shortening of the journey between Lyons and Turin with its not unimportant implicit military advantages. Knowing with whom he had to deal through first-hand experience in Egypt, Fourier restricted his memoir to a single page containing nothing but the essential features of the scheme and the principal advantages to be expected from it together with a map of the route. His insight into Napoleon's character was fully justified and two days later the request was granted.[59] Thereafter all opposition, including that of the Minister of the Interior, melted away and by 1814, when work had to be stopped following the downfall of Napoleon, the road had been opened up as far as the Italian frontier. Thereafter its continuation hung fire to the chagrin of those who had expended so much work and money on its execution. That part of the road opened up was eventually completed providing a carriageway as far as Briançon.

3. Friendship with Bonard

A number of letters written by Fourier during his time in Isère bear witness to his continued friendship with Bonard up at least to the year 1810. These letters deal mostly with matters of purely personal interest to Fourier and Bonard only. Thus in one letter[60] Fourier asks Bonard to carry out a number of small tasks including payments to a friend and to a nephew. He also requests Bonard to help buy one of his brothers out of the army. This particular brother may have been the black sheep of the family because Fourier states that 'as soon as he has retired from the service I shall give him a small pension and inform him how I wish him to use it; it is also my intention that he remain at Auxerre'. Fourier was very evidently the head of the family. In another (undated) letter[61] he announces his imminent arrival at Auxerre where he hopes to stay with Bonard. Unfortunately no account has survived of his reunion with Bonard and other friends in Auxerre. No doubt they had many experiences to exchange, and many reminiscences of the old days in Auxerre, especially during the Terror. In two other letters[62] he mentions the question of placing one or two of Bonard's children in a Lycée. Bonard, who had been Professor of Mathematics at the École Centrale in Auxerre, was offered the same position in the Secondary School which was planned to take its place under the Napoleonic reorganization of French education. But Bonard declined this position. His letter of refusal has been preserved and is worth quoting in

full for the vivid impression it gives of the integrity and independence of the man:

> I have been informed that I was nominated by the Minister of the Interior as Professor of the 5th and 6th classes of mathematics at the Secondary school.
>
> I am very flattered by the pleasant things which you have seen fit to say about me. I should like to justify the confidence with which I have been honoured. But various considerations require me to take a line which if not conformable to my tastes is at least authorized by circumstances.
>
> To continue a career which I have followed for 24 years would seem to imply that I could not but accept. Should I accept? It would be necessary for me to have an idea of the extent of the duties which I would be required to fulfil and of the advantages which I should derive from them, [for] my position requires me to take account of my own interests in the employment of my time. I have also other motives. My physical facilities would not permit me to employ in this position all the zeal and activity that it requires. Although mathematics is a science of reflection its teaching is susceptible of action and passion. To convince young people it is necessary to show the same warmth which is required in oratorical declamations. The feebleness of my constitution warns me that it is time to renounce a position which could have an unhappy influence on my health which I wish to retain for my children's sake.
>
> Moreover, I will state frankly that filled with a sense of the importance and dignity of the calling of those who instruct youth, I see with displeasure that in the actual organization the teacher will not be given all the consideration which alone makes up for the pains and sacrifices to which he is condemned in fulfilling the task imposed on him.
>
> Moreover the government establishes the uniformity of teaching to give it a good direction. This is wise. But I would have some observations to make on the choice which has been made for mathematics.
>
> My decision is therefore unequivocal, I return my nomination. I hope that the bureau of administration whose good opinion I greatly prize will not find it reprehensible that I do not accept a place which suits neither my moral nor my physical dispositions. I am grateful, and I would regard any circumstance as fortunate in which I could convince the administration of my veneration and gratitude.[63]

It is not known how Bonard employed his time after his retirement from official teaching. He probably continued to teach mathematics privately, and his own mathematical ambitions, long dormant in favour of his pupils, especially Fourier, evidently revived momentarily as appears from the following letter to Lalande,[64] then one of the permanent secretaries to the Académie des Sciences:

> I take the liberty of addressing to you the result of some researches which have as principal object the properties of parallels. This theory has not yet been treated as one would like it to be: if I have managed to present it in a more satisfactory

manner than has been done up to the present my work will contribute to perfecting an important part of elementary geometry and will not be useless.

To fulfil my object I have believed it necessary to take the elements of geometry from the beginning because of the preliminary propositions which I have to bring out, and there are certain parts which I present in a new way. The whole treated very succinctly is the fruit of reflections that a long practice in teaching have put me in a position to make.

If you consider, Sir, that this essay would not be unworthy of the attention of the most able mathematicians, please be good enough to present it to the class of mathematical sciences of the Institut; it is the right way to find out the degree of interest which it merits. Full of confidence, Sir, in your wisdom and indulgence I am persuaded that you will know how to appreciate my work, and if there is any indiscretion in my initiative I hope you will be good enough to excuse me.

Please receive, Sir, the homage of my consideration and respect.

Bonard[65]

The paper referred to is entitled 'First notions of elementary geometry', and has been preserved.[66] It is remarkable only for the extreme clarity of its presentation. A note by Lalande praises one happy construction, points out an error in another, and the incompleteness of a further one, and ends with the judgement: 'all told, this work hardly merits being presented to the Institut'.

Thus ended Bonard's private mathematical ambitions. Thereafter, he had to content himself with the success of Fourier and possibly other of his pupils, and of his own children.

The last extant letter from Fourier to Bonard was dated 25 February 1810. Unlike the other letters which are mostly little more than hurried notes, this one is full of an affectionate tenderness which speaks of Fourier's real feelings for his friend:

Paris, 25 February 1810

My dear old friend,

I do not know how to ask your forgiveness for the continual delays in my correspondence, though they can only in part be blamed on my negligence; for the circumstances in which I have found myself for several months have demanded my exclusive and total attention.[67]

I have written today to Grenoble and instructed the person responsible for my affairs to send you immediately the sum of 800 francs to which you refer in your letter.

My letter will arrive on 1 February (*sic*) and you will certainly receive the sum in question by the 6th or 7th of next month. If, however, you find this delay somewhat inconvenient please be good enough to write to M. Guichard the post office director, and request from him on my behalf the sum of 800 francs. I know his friendship for me well enough to be certain that he will accede to your request. Please give my regards to Mme Bonard and thank her for what she has done for my niece. I shall do my best on my return to spend a day or two at Auxerre. When you remember me to M. Guichard, tell him how much I regret not having seen him when he was last at Paris; I often meet M. Dumoland, his friend, at court and we talk about him.

At last I am coming to the end of my troubles, the printing of my discourse will soon be finished. I shall then devote more time and care to my personal affairs. In continuing to have recourse to your kindness I shall try to repay it better than I have done up to the present. Please remember me to M. Roux and give me news of his health.

Accept the assurance of all the feelings of gratitude which I owe to your long standing friendship.

J. Fourier
Prefect of Isère[68]

With this affectionate letter we say goodbye to Bonard. The demand for 800 francs may have been in payment of a debt owed him by Fourier who was remarkably disorganized in his financial affairs. If it was due to Bonard's own impecuniosity we can be sure that Fourier would have helped him generously during the last years of his life up to his death in 1819, unfortunately three years before the publication of the Analytical Theory of Heat. Of these years nothing is known. Bonard would certainly have had friends in Auxerre, his wife who was still alive in 1810 may well have outlived him. As for the children for whose sake he had wished to safeguard his health in 1804, one son Alphonse[69] became the owner of a hotel in Auxerre while another—the same René whom the abbé Fourier had baptized—had a successful career in the army medical service ending as medical officer in charge of the military hospital at Calais. As successful a father as he was a teacher, Bonard was evidently one of those on whom the health of the *res publica* ultimately depends.

Notes

1. As Professor of Mechanics and Analysis at the École Polytechnique Fourier could certainly have been regarded as a 'subordinate' of the Ministry of the Interior under whose control the school then lay. So that it is just possible that he was not asked whether or not he wished to be 'disposed of for the sake of public service'. This was certainly the case with the physicist E. L. Malus, who as a serving engineer was simply ordered to proceed to Toulon—much to his chagrin as he was just about to marry Fraulein Koch, the daughter of the Chancellor of the University of Giessen, in which town he happened to be stationed as a member of the French army of occupation. In other cases preliminary soundings were first made. Thus so important a person as Gaspard Monge was *invited* to join the expedition in a letter signed by all five Directors. Monge at first refused, no doubt much to the chagrin of Bonaparte, who not only appreciated Monge's rare gifts as a mathematician and scientist—not to say as a collector of *objets d'art* in enemy territory—but also genuinely loved him as a friend, an emotion fully reciprocated by Monge who never wavered in

his devotion to Bonaparte. The latter, however, was not the man to accept a simple refusal. He soon realized that it was Madame Monge who stood in the way of Monge joining the expedition. She was evidently a formidable woman who had no intention of allowing her 'silly old husband' to join the expedition. But after two personal visits by General Bonaparte she was forced to capitulate, and Monge later embarked at Civitta-Vecchia with the contingent under General Desaix. At Bonaparte's suggestion he carried with him a number of useful effects including the Arabic press of the Holy Office and 800 bottles of the finest wine from the cellar of Napoleon's brother Joseph.

In other cases possible recruits for the scientific side of the commission were approached by either Berthollet or Caffarelli who had been charged with this task by Bonaparte. Not all those approached accepted. Thus when Berthollet visited Cuvier and Geoffroy Saint Hilaire in the Museum d'Histoire Naturelle and invited them to join the expedition with the irresistible words 'Come, Monge and I will be your companions and Bonaparte your general', the impetuous, warm-hearted Saint Hilaire accepted while the more reserved and calculating Cuvier refused. Certainly Cuvier had a good excuse, being deputy to a very ancient professor whose days were evidently strictly numbered and whose chair Cuvier had every intention of occupying at the first possible moment. But Cuvier, shrewd man that he was, may also have calculated that an expedition to unknown parts under the mercurial and unpredictable Bonaparte—wasteful, as Herold notes, of nothing but human lives—might not have been very profitable from an academic point of view.

2. Although Bonaparte may well have discussed the organization of the commission of arts and science to be attached to an eventual Egyptian expedition with Monge in Italy in 1797, it seems that the idea of such a commission—as opposed to that of the expedition itself—was Bonaparte's own, though he almost certainly had in mind the scientific contingent of Alexander's expedition to the East. Bonaparte's interest in science seems to have waned somewhat in later years, but in 1798 he had a genuine enthusiasm for the subject, and imagined that he might have made an alternative career in it for himself. (An interesting discussion of Bonaparte and French science is given in Crosland, chapter 1. See also Barral.)
3. See Crosland, p. 15.
4. On leaving Paris the members of the Scientific and Literary Commission had fondly imagined they would form an homogeneous group. In the event they were divided into five classes, the first class being paid at the rate of 6000 francs per annum, each subsequent class being paid 1000 francs less than the next one above. In letters to Cuvier from Toulon of 9 and 18 May 1798, Geoffroy Saint Hilaire describes how unhappy many members of the commission were at their lowly classification. He himself was one of six members of the top class and as such dined at tables of ships' captains where he ranked as a superior officer. No doubt Fourier, then a full professor at the École Polytechnique, also travelled first class, though there appears to be no specific indication that this was the case.
5. Kléber, Jean Baptiste (1753–1800). He was trained as an architect in Paris and later served for a time in the Austrian Army. He returned to Alsace and joined the Republican forces in 1792 serving with distinction in the war of Vendée. He was dismissed for the crime of having spared the lives of 4000 prisoners taken at St. Florent, but was recalled in 1794 and sent to the Army of the North under Jourdan where he played a decisive part in the battle of Fleurus and in the capture of Frankfort in July 1796. He then retired for a while and wrote his memoirs but returned for the Egyptian Campaign where he greatly distinguished himself especially in Syria and at the battle of Aboukir. In company with Desaix, Hoche, Joubert, and Marceau, Kléber was one of the greatest of the generals of the Republic (*Bio. Gen.*; *Gde. Encycl.*; *Gd. Lar.*).

6. Tallien, J. L. (1767–1820). Elected to the National Convention where he sat with the Mountain and became a member of the Committee of General Security. He was the leader with Fouché in the conspiracy against Robespierre and was one of the most active Thermidorians. He was saved from exile in 1816 through the friendship of Decazes, the favourite of Louis XVIII.

   Napoleon seems somehow to have got wind of Fourier's revolutionary past—possibly from Fouché, who could have seen Fourier's dossier in the files of the Committee of General Security—for during his passage through Grenoble during the Hundred Days he first accused Fourier of having voted in the Convention for the death of the King, and when he was assured that Fourier had never been a member of that body he persisted in maintaining that Fourier had signed a document in Auxerre calling for the trial of Louis. J. J. Champollion-Figeac, who relates this story, later took the trouble to verify that Fourier was not a signatory of the address in question, probably the one of October 1792 of which part is reproduced above in chapter 2, p. 16.
7. Malus, Étienne Louis (1775–1812). He was the son of Louis Malus du Mitry, treasurer of France. Educated at home in literature and mathematics, he was sent to the school of Mézières but was dismissed as a suspect in 1793 when he enrolled in the army and was sent to Dunkerque. There his talents were noticed by the engineer Lepère who had him sent to the École Polytechnique. Monge had already noticed him at the school of Mézières and chose him as one of the special band of brigade chiefs, taught by himself, who were destined to instruct others. Malus was perhaps Fourier's most brilliant pupil at the École Polytechnique. During three years he devoured works on mathematics and began to write original papers on the path of light in media of variable refractive index. He then returned to the army and was present at the passage of the Rhine in 1797. He took part as an engineer in the Egyptian Campaign where he repeatedly distinguished himself. On his return to France he took up his work in science again and was awarded a prize for physics at the Académie des Sciences in 1810 for a memoir on double refraction. The previous year he had published an account of his discovery of polarization by reflection. He was elected to the Académie des Sciences in 1810 and in spite of the war between England and France was awarded the highest honour of the Royal Society of London, the Rumford medal, on 22 March 1811. His death the next year at the age of thirty-seven was a grievous loss to French science (*Bio. Univ.*; *Bio. Gen.*; *Gde. Encycl.*; *Ind. Bio.*).
8. Malus, p. 88.
9. See Letter III, n. 3, Appendix, p. 253.
10. See Letter VI, n. 15, Appendix, p. 266.
11. Conté, Nicolas Jacques (1755–1805). Orphaned at an early age, he took up portrait painting from which he derived considerable profit but later devoted himself to mechanical arts and the study of science and mathematics. In Paris he followed the lessons of Vauquelin and presented to the Académie

des Sciences a hydraulic machine of his own invention which was much praised. After the outbreak of the Revolution, especially after war had been declared against England, he exercised much ingenuity in finding substitutes for materials which could no longer be imported. From 1796 onwards he was associated with Monge and Berthollet in researches into balloons and became the Director of the Aerostatic School at Meudon. He also played a part in the setting up of the Conservatoire des arts et métiers. He took part in the Egyptian Expedition as head of the ballooners. After the disaster of Aboukir and the revolt of Cairo—when a great part of the instruments and material brought by the French to Egypt were destroyed—he exercised miracles of ingenuity in constructing utensils and machines of all kinds from simple windmills to money mints. Thanks in great part to his activity and genius the expedition was provided with bread, linen, arms and munitions, engineers were provided with precision instruments, and doctors with surgical instruments. According to Monge he had 'all the sciences in his head and all the arts in his hand'. Napoleon found him 'good for everything'. On returning to France in 1802 he was charged by the Minister of the Interior Chaptal with the direction of the publication of the work of the scientific and literary commission of Egypt. He invented a printing machine which considerably reduced this work but did not live to see it completed. He was one of the first members of the Legion of Honour (*Bio. Gen.*; *Gde. Encycl.*).

12. Geoffroy Saint Hilaire, Étienne (1772–1844). After receiving his early education at the Collège de Navarre he intended to enter the Church, being appointed to a canonry in the chapter of Saint Croix at his native town of Étampes with permission to stay in Paris to study law in which he took his primary degree in 1790. By this time he had already been much attracted to science by the lectures in experimental physics of Brisson and had begun the study of medicine. After the fall of the Throne on 10 August 1792 all the masters of the Collège du Cardinal-Lemoine where Saint Hilaire was then in residence were arrested as non-juring priests. Following vigorous representation Saint Hilaire managed to have two of these priests released including his teacher and friend the Abbé Haüy. On 2 September he penetrated the prison of Saint-Firmin in disguise and tried to persuade the other professors to escape. But they refused and were all massacred. The same night Saint Hilaire managed to save the lives of twelve other prisoners. Overcome with fatigue and sorrow he returned to Étampes where he fell dangerously ill. When he eventually recovered he returned to Paris where he took up the study of botany on the advice of Haüy, and on the reorganization of the *Jardin des Plantes* as the *Muséum d'Histoire Naturelle* he was appointed to one of the twelve new chairs sharing the teaching of zoology with Lamarck. It was he who recognized Cuvier's genius and had him appointed to a position in Paris in 1794. In Egypt he investigated the flora and fauna of the Nile delta and was a member of the commission set up to organize the Institute of Cairo. He is said to have saved the collections of the scientific commission for France by threatening to burn them rather than give them up to the British in conformity with the terms of the capitulation of 31 August 1801. After the Convention of Cintra in 1808 he once again persuaded the British to allow him to retain a collection he had made during a visit to Portugal. He became Professor of Zoology at the Faculty of Science in 1809 having been called to the Institute in 1807. In 1830 he opposed Cuvier in a famous controversy over the question of the fixity of species which played an important part in the pre-history of the theory of evolution (*Bio. Gen.*; *Gde. Encycl.*).

13. Say, Jean Baptiste (1767–1832). After a period of apprenticeship with a London businessman he became a journalist. Adam Smith's 'Wealth of Nations' interested him in economics and his *Traité d'Économie Politique* (1803) was very influential. The famous law of supply and demand bearing his name was the central tenet of orthodox economics until the great depression of the 1930s. After the Restoration he taught political economy at the Athenée (1816), the Conservatoire des arts et métiers (1821), and the Collège de France (1830) (*Bio. Gen.*; *Gd. Lar.*).
14. Denon, Dominique Vivant (1747–1825). French designer, engraver, and diplomat. He was destined for the law but turned instead to arts and literature. He distracted the aged Louis XV by his brilliant conversation and was given various diplomatic tasks. While in Switzerland he slipped unnoticed into Ferney and drew the famous *Déjeuner à Ferney* and the portrait of Voltaire. He became a member of the Académie de Peinture in 1787. At the outbreak of the Revolution he was in Italy and he owed his omission from the list of *émigrés* to the intervention of David, for whom he then drew the famous *Serment du Jeu de Paume*. He also drew a striking picture of Barère at the Tribune. He attached himself in due course to General Bonaparte and made himself pleasant to Josephine. He accompanied the Egyptian expedition and made an important contribution to the *Description of Egypt* by his drawings and descriptions of ancient Egyptian monuments. He was the director of all Napoleon's major monumental works and accompanied him on his most important campaigns. He initiated the policy of enriching the Louvre with works taken from conquered lands. He was one of the first to practise lithography (*Gde. Encycl.*; *Bio. Gen.*).
15. Fourier was elected permanent secretary at the first *séance*. He was then at Rosetta and his place was temporarily taken by Costaz who had obtained the next largest number of votes after Fourier. The minutes of the first two séances (6 and 11 Fructidor Year VI) are signed by Costaz alone, the next two minutes are signed by Costaz and countersigned by Fourier, and the next minutes (26 Fructidor) by Fourier alone (*Bib. Inst.* MS. 3818).
16. Some of the greatest urgency following the destruction of the French fleet and along with it instruments and appliances of all kinds.
17. The additional five or six days beyond the 360 provided by the twelve revolutionary months of thirty days were originally, and appropriately, termed *jours sans-culottidiens*. By Year VI the *sans-culottes* had long been out of favour, and the term had been changed to the politically neutral *complémentaires*.
18. Cousin, pp. 13–14.
19. Ibid., pp. 19 and 22.
20. Andréossy, Antoine François, Count (1761–1828). He gained rapid promotion in the Italian and Egyptian campaigns. He was a distinguished member of the Commission of Arts and Sciences in Egypt, and published several memoirs in the *Description of Egypt* including one on the valley of Lake Natron. He returned to France with Napoleon and actively assisted him in his subsequent rise to power, being rewarded with the control of artillery and engineering in the Ministry of War. He retired after the second Restoration and devoted himself entirely to scientific work of a geographical and geological nature. He was elected to the Académie des Sciences in 1824 (*Bio. Gen.*; *Ind. Bio.*).

21. Caffarelli was one of the heaviest losses to the expedition. Malus contracted plague, and though he cured himself by the exercise of indomitable willpower, his health was broken and he died early in 1812. Monge also took dangerously ill but recovered.

Caffarelli, Louis Marie Joseph Maximilien (1756–99). He was a member of an Italian family which had settled in France in the reign of Louis XIII. He was educated at Sorèze where he distinguished himself especially in mathematics, and later he entered the engineers. In 1792 he served as an officer of the engineers in the army of the Rhine. At first he was an enthusiastic revolutionary but was later dismissed for having protested against the day of 10 August and the deposition of the King. On his return home he was imprisoned for fourteen months, but was reinstated in his position in 1795 when he served with distinction in the army of the Sambre and Meuse and had a leg carried away by a bullet on the banks of the Nahe. He retired to Paris for a while and became a member of the Institut. He took part in the Egyptian Expedition as chief engineer and died before Acre from a wound to one of his arms which had to be amputated. He was renowned for his bravery, and was very popular with the soldiers who called him 'wooden leg'. Caffarelli published a number of memoirs on public education and several scientific works (*Bio. Gen.*; *Gde. Encycl.*).

22. Smith, Admiral Sir William Sidney (1764–1840). He entered the Royal Navy in 1777 and saw service in the American War of Independence. In 1785 he went to France where he resided for two years, mostly at Caen, and acquired a liking for French civilization along with a complete mastery of the French language. In 1787 he took a journey through Morocco and in the summer of 1789 proceeded to Sweden where he took a prominent part in a naval war between Sweden and Russia as a result of which he was made a Knight Grand Cross of the Swedish Order of the Sword. He next proceeded to Constantinople. Finding himself without transport when ordered home in 1793 he bought a sloop at Smyrna at his own expense, and with a crew of forty other benighted British seamen sailed to Toulon to join Lord Hood in his operations against the republican forces besieging the town. During the evacuation Smith was put in charge of the burning of French ships in the port, an operation which was not entirely successful. He made himself extremely unpopular at this time with other officers through his high-handed manner and excessive self assertion. From 1795 onwards he was employed on various harrying operations on the French coast in the course of which he was captured at Le Havre in 1796. Proposals for his exchange were refused by the French government who were by this time thoroughly exasperated at his activities, and he was imprisoned for a period of two years in the Temple prison in Paris. Ultimately he escaped with the help of a Colonel Phillepeaux, a former officer of the royal French army and class-mate of Napoleon at Brienne. With Phillepeaux Smith played a memorable part in the defence of Acre against Bonaparte, and for his services received the grateful thanks of both houses of parliament and a pension of £1000 per annum. Smith's success at Acre rekindled his thirst for independent command and he took it upon himself to sign with General Kléber the Convention of El-Arish (24 January 1800) according to which the French forces in Egypt were to be transported bag and baggage to France at the expense of the Sultan and his allies. But Lord Keith disowned the Convention and the war was recommenced. Ultimately, however, the terms for the capitulation of the French forces in Egypt differed little from those originally agreed with Kléber though many thousands of lives, including that of Kléber himself, had been lost in the meantime. Smith returned home in 1801, was promoted rear-admiral in 1805, and vice-admiral in 1810 when he was placed second in command of British naval forces in the Mediterranean. He returned to England in 1814 in very bad health but nevertheless characteristically managed to be present as an observer at the Battle of Waterloo, and had the curious distinction of being invested with the K.C.B. by the Duke of Wellington in the Palace Bourbon in Paris on 29 December 1815. He was promoted admiral in 1821. He spent the last years of his life in Paris where he became head of the Order of St. John of Malta in France, and died in Paris on 26 May 1840 being buried close to his wife in the cemetry of Père Lachaise where a monument was erected to his memory (D.N.B.; *Gde. Encycl.*; Barrow; Herold).

23. Herold, p. 325.

24. Idem.

25. Costaz, Louis, Baron (1767–1842). He was a *maître des conférences* at the École Normale in 1795, and became an examiner at the École Polytechnique in 1796. He played a large part in the foundation of the Conservatoire des arts et métiers. In Egypt he was assistant secretary to the Cairo Institute and contributed to the *Description of Egypt*. He was successively Prefect of the Manche (1804), Director General of *Ponts et Chaussées* (1813) and Counsellor of State (1814). After Waterloo he devoted much time to the encouragement of French industry. He was elected to the Académie des Sciences in 1831 as a free *académicien* (*Bio. Gen.*; *Gde. Encycl.*; *Ind. Bio.*).

26. For example, before Bonaparte's departure there had been an insurrection in Cairo in October 1798 in which the Institute, then housed in the palace Qassin Beg, had only been saved by the resolute action of Monge and Berthollet who insisted in holding out till help arrived from the army.

27. Herold, p. 368.

28. Menou, Jacques François, Baron de (1750–1810). Of an ancient family of the nobility, he entered the army and was elected to the States General, where he played a leading part in army reforms and in the Constituent Assembly. After the flight from Varennes he was one of the founders of the Society of Feuillants. He was in command of the troops in the Château of the Tuilleries on the night of 9–10 August, but was nevertheless continued in his command and fought in the Vendée. His defeat there led to an act of accusation against him by Robespierre. He appeared at the bar of the Convention but was saved by Barère. He was made a general after 9 Thermidor. He repressed the Faubourg Saint Antoine after the insurrection of 1 and 2 Prairial Year III and as a result was put in command of the Army of the Interior. But he was replaced by Bonaparte on 13 Vendémiaire for his conciliatory attitude to right-wing insurgents on that day and remained in retirement till the Egyptian Campaign when he was put in charge of a division. After succeeding Kléber as commander-in-chief in Egypt he married a Mohammadan and was converted to Islam taking the title Abdallah. He was defeated by the British invasion force at Canopus (21 March 1801) and finally capitulated on 31 August of the same year. By the terms of the capitulation he was able to bring back the French army to France. Through the favour of Napoleon he was then given various positions in Italy including that of Governor General of Tuscany (1808) and Venice (1809). According to the Duke of Ragusa, Menou was devoid of almost

all military virtues except bravery, was an incurable procrastinator—after he left Piedmont 900 unopened letters were found in his office—ceaselessly absorbed with trivia of all kinds, and he seems to have owed his continued employment after his return to France to the fact that he had constantly put himself at the head of the pro-Bonaparte party in Egypt. Napoleon would also have been unlikely to forget that it was Menou's indecision on 13 Vendémiaire which made possible his own rise to power. (*Bio. Gen.*; *Gde. Encycl.*).

29. Desaix, Louis de Veygoux (1768–1800). He belonged to a noble family in straitened circumstances. After attending the École Royale Militaire at Effiat he entered the army in 1783, and in 1789 he embraced the revolutionary cause. He fought under Jourdan and Moreau and played a brilliant part in the campaigns of the Army of the Rhine. On a visit to Italy he allied himself with Bonaparte whom he followed to Egypt. He led the operations against Murad Bey in Upper Egypt where his wise government earned him the title of 'The Just Sultan' among the Arabs. Disapproving of the Convention of the El-Arish he returned to France in March 1800 and died gloriously on the field of Marengo after his last minute intervention had saved Bonaparte from defeat. The latter regarded Desaix as the most able of all his lieutenants (*Gde. Encycl.*).
30. Champollion-Figeac, J. J., p. 18.
31. Belliard, A. D. (1769–1832). He entered the Army and was in charge of Dumouriez's headquarters at Jemmapes where he displayed great bravery. After the defection of Dumouriez Belliard was arrested and dismissed from his position. Thereafter he enlisted as a private soldier and had begun to reclimb the military ladder when he was given back his previous position by Hoche. He fought through both the Italian and Egyptian campaigns with great distinction. Besieged in Cairo by greatly superior enemy forces, he nevertheless managed to obtain very favourable terms and was given command of the 24th military division on his return to France. In 1805 he was made chief of staff to Murat and took part in the Spanish and Russian campaigns where he again distinguished himself. On the First Restoration he was named Major General and Peer of France. On the return of Napoleon he accompanied the royal party as far as Beauvais, refusing to leave them until ordered to do so by Louis XVIII himself. For the remainder of the Hundred Days he again supported Napoleon and was arrested after the Second Restoration but was pardoned and readmitted to the Chamber of Peers three years later. Louis Philippe appointed him Ambassador to Belgium where he was French Signatory to the Treaty which separated Holland and Belgium (*Bio. Gen.*; *Gde. Encycl.*).
32. Geoffroy Saint-Hilaire, p. 216.
33. Fourier Dossier AdS.
34. See below Letter XII, Appendix, p. 292.
35. Fourier Dossier AN: Item 5 of Appendix to Fourier's Letter of 20 Nov. 1815 to Minister of Interior.
36. Champollion-Figeac, J. J., p. 22.
37. Cousin, p. 28.
38. We remember also that Cuvier's firm refusal to accompany Bonaparte to Egypt seems to have had no adverse effect on his rapid promotion under the Napoleonic régime.
39. Fourier Dossier AN: nomination of Fourier as Prefect of Isère.
40. Chaptal, Jean Antoine (1756–1832). On graduating in medicine at Montpellier he went to Paris to complete his studies. He returned to Montpellier in 1781 to take up a new chair of Chemistry in the School of Medicine. He early adopted Lavoisier's new theory of chemistry which he expounded with great clarity and power. He made many important contributions to applied chemistry. On inheriting his uncle's fortune he devoted his wealth to founding factories where chemistry could be applied to industry. The Government rewarded all his many services to the State by letters of nobility and the order of Saint Michel. In the Revolution he took the side of the Girondins against the Montagnards in his '*Dialogue entre un Montagnard et un Girondin*' which led to his arrest after the insurrection of 31 May. But his friends in Montpellier easily obtained his release and he left for Paris where he was made director of the manufacture of saltpetre at Grenelle. He was charged with the reorganization of the École de Médecine where he lectured in chemistry until 1797.

    After 18 Brumaire he became Minister of the Interior on the retirement of Lucien Bonaparte. In this position he made important improvements in hospitals, and in industrial and technical education. He retired in 1804 partly through dissatisfaction with the loss of public education to his ministry. On Napoleon's return from Elba Chaptal accepted the direction of commerce and manufacture. For this defection Louis XVIII had him struck off the roll of peers, but he was reinstated several years later, and thereafter contributed as Counsellor of State to the improvement of commerce and industry. He was elected to the *Institut* in 1796. (*Bio. Gen.*; *Gde. Encycl.*; *Ind. Bio.*; Pigeire).
41. Fourier Dossier AN: nomination of Fourier as Prefect of Isère.
42. Ibid.
43. Letonnelier, p. 137.
44. Champollion-Figeac, A. L. (2), p. 141.
45. Ibid., p. 163.
46. Ibid., p. 149.
47. In this task Fourier was assisted by the history of the ancient province of the Dauphiné to which the region of the department of Isère had originally belonged. The Dauphinois, in fact, had played a memorable part in the events immediately preceding the convocation of the Estates-General in March 1789 only rivalled by the turbulent Bretons. Thus the *parlement* of Grenoble had been the first to demand (21 August 1787) the convocation of the Estates-General. The reforms of Lamoignon, including the suspension of provincial *parlements*, produced a popular uprising in Grenoble on 7 June 1788, the famous 'day of tiles' on which the angry populace rained down tiles on the King's soldiers massed in the narrow streets of the town. Soon after the so-called Assembly of Vizille (21 July 1788), composed of representatives of the three estates, especially the third, demanded the re-establishment of the *parlements* and the convocation of the Estates-General. In that latter body representatives of the Dauphiné again played a leading part, and two of them, Mounier and Barnave, were leading figures in the Constituent Assembly. But the Revolution eventually went too far for the early representatives of the Dauphiné and the constituents who elected them. Although there was a strongly held local tradition of freedom of thought—possibly related to the high proportion of Protestants in the province who still made up a quarter of the population as late as 1720—this love of freedom went with an equally strong belief in good government natural to a province which had been exceptionally prosperous from around 1730 onwards, and which contained no concentrations of urban proletariat as in Paris or Lyons. From all this it followed that it was

quite natural for the Dauphiné as a whole, and Isère in particular, to welcome the Napoleonic regime with its promise of strong and stable government, and—equally important—its guarantee of the retention of the important gains which the Revolution had brought to the lower and middle classes at the expense of the nobility. Statistics bear out this supposed initial popularity of the Napoleonic regime. Thus when a plebiscite was taken in 1804 regarding hereditary establishment of the imperial throne in the family of Napoleon, the voting in the department of Isère was 80 000 to 12 in favour. And when Napoleon passed through Isère in 1805 on his way to Milan more than 10 000 people from the department turned up at Bron to cheer him on his way (*Gd. Lar.*; *Letonnelier*).

48. Champollion-Figeac, A. L. (1), p. 79.
49. Cousin, p. 32.
50. Ibid., p. 32.
51. And possibly by discreet reference to the Blessed Pierre Fourier, of whom he is said (Champollion-Figeac, J. J., p. 41) to have spoken with great pleasure in Grenoble. He was indebted to Champollion-Figeac for obtaining both a biography and a portrait of his saintly great-great-uncle. Fourier made good use of this portrait during a stay of King Charles IV of Spain at the prefecture on his way through Grenoble. With a somewhat un-Jacobin regard for royalty Fourier had personally supervised all the arrangements of the King's visit with great care, but had forgotten to provide a crucifix. The King had unfortunately forgotten his too, and asked to borrow Fourier's. The latter had probably disposed of his by 1793 at the latest, and to cover up his embarrassment produced the portrait of the blessed Pierre Fourier while a crucifix was being fetched from a nearby church (Champollion-Figeac, J. J., p. 41).
52. Letonnelier, p. 138.
53. Perier, Augustin (1773–1833). He was counsellor in the *parlement* of Grenoble and entered the École Polytechnique at its foundation, returning later to his native town where he occupied himself actively with industry. In 1815 he was elected representative of the Rhône in the Chamber of the Hundred Days where he sat with the majority. He stood without success for Isère in 1819 and 1820 but was elected by the same department in 1827 sitting to the left of centre. He signed the address of the 221 and was re-elected in 1830, co-operating actively in the establishment of the July government and in the revision of the Charter. But he opposed any extension of political liberties and consequently failed to be re-elected in 1831. Created a peer of France in 1832, he took an important part in debates and in parliamentary work (*Bio. Gen.*; *Gde. Encycl.*).
54. Cousin, pp. 29–30.
55. Fourier Dossier AN: item 9 of appendix to Fourier's letter of 20 Nov. 1815 to Minister of Interior.
56. Ibid., item 7.
57. Fourier Dossier AN: Letter of 28 March 1816 to Minister of Interior.
58. Crétet, E. (1747–1809). Deputy of the Côte-d'Or in the Council of Five Hundred, he became counsellor of state after 18 Brumaire, director of *Ponts et Chaussées*, governor of the *Banque de France* (1806) and Minister of the Interior (1807).
59. Cousin, p. 30.
60. See below Letter XIII, Appendix, p. 297.
61. See below Letter XVI, Appendix, p. 301.
62. See below Letters XIV and XV, Appendix, pp. 298, 299.

63. Cestre (3) (1915), p. 454.
64. See below Letter VI, n. 5, Appendix, p. 263.
65. *Bib. Inst.* MS. 2041 fol. 383. The letter is dated 30 Ventôse Year XIII.
66. Ibid., item 66.
67. Fourier was in Paris for a number of months towards the end of 1809 and the beginning of 1810 to supervise the printing of his introduction to the *Description of Egypt*.
68. *Bib. Mun.* Aux. MS. 335. For completeness' sake it is reproduced below as Letter XXII, Appendix, p. 322.
69. It was he who presented to the Municipal Library of Auxerre the precious collection of letters from Fourier to Bonard.

5

YEARS OF EXILE: GRENOBLE AND LYONS

1. Extra-prefectorial duties

THE draining of the swamps of Bourgoin and the opening of the French part of the new road from Grenoble to Turin were the major public works carried out in Isère during Fourier's prefecture, and he had a right to be proud of the part he played in both projects, especially the former. But he also contributed as prefect in many other ways to the life of the department. For example, he interested himself in individuals of promise in the department and did what he could to see them launched on their careers. Thus he used his position as prefect to prevent Champollion-Figeac the younger[1] from being conscripted by the simple expedient of ignoring repeated letters from the Minister of War while at the same time writing himself to various influential people on behalf of Champollion.[2] Eventually Fourier carried the day, the Minister was forced to retire, and Champollion was saved for his true *métier* of Egyptology, a subject to which he had in fact been introduced by Fourier himself.

As an ex-member of the bibliographic commission at Auxerre during the Terror, and as candidate for the position of director of the projected municipal library in that town in 1794, it is not surprising to find Fourier the prefect active in acquiring books for the municipal library in Grenoble. Indeed his policy of a rapid build up of books put the library heavily in debt for a number of years. This, however, as Champollion[3] wisely observes, was but an illustration of Fourier's discernment of the difference between public and private bodies in the matter of indebtedness.

He also took a keen interest in the Society of Arts and Sciences at Grenoble having been elected to the first place to fall vacant after his appointment as prefect.[4] He was apparently not very assiduous in attending ordinary meetings of the Society though he was always present at public *séances* and at extraordinary meetings. To this society he communicated all matters of interest which came to his attention through correspondence and reading, and he also read several memoirs at public meetings including a discourse[5] on the sciences remarkable for its Baconian emphasis on the obligation of science to serve the good of mankind. He founded two prizes in the Society, one in mineralogy, an appropriate subject in a region as rich in mineral deposits as Isère, and one in statistics.[6]

One of the most troublesome and time-consuming of Fourier's undertakings during his stay in Isère was his contribution to the *Description of Egypt*. The idea of this work went back at least to a letter[7] of Kléber of 22 November 1799 to the Institute of Cairo following the return of the expedition to Upper Egypt under the joint direction of Fourier and Costaz. Having referred to

> the truly liberal and patriotic idea of joining together so many fine things in one great work, and where possible placing the objects in the national collections . . .

Kléber continued,

> In consequence I desire that prompt measures be taken to ensure the writing of the various works, the distribution of topics, and the choice of the person responsible for directing the whole of this fine work and for linking together its various parts. The Institute will feel the need for a general introduction written all of a piece.

By the almost unanimous vote of a joint meeting of the commissions and the Institute, Fourier was chosen to 'unite and publish the collection of works'. The exigencies of war inevitably delayed the project, but it had been known to the French government in a letter of 23 June 1800, and after the return of the expedition to France the idea of a general description of Egypt was renewed by an order of 6 February 1802, the production of the work to be at the expense of the State and the contributors to be paid their former salaries as members of the Egyptian expedition. They were also to share among themselves the proceeds of the sale of the work. According to a letter from Monge, Fourier was to be charged with

> forming a list of the persons who should make up the assembly of savants and artists returned from Egypt; all the members of the Institute of Cairo were to belong to the assembly except those who could not contribute to the required labours.[8]

After the plates of the work had been put in hand the question of writing arose, especially of the preliminary discourse, and of the editing of the whole work. Once again, as in Egypt, the assembly of contributors chose Fourier as editor of the general introduction.[9] According to Champollion-Figeac,[10] Fourier composed this introduction with painstaking care—no doubt realizing how carefully Napoleon would scrutinize the result. Towards the end of his task he isolated himself in a country residence[11] some two leagues from Grenoble where he could devote himself entirely to the final polishing of his work. In the autumn of 1809 the preliminary discourse was at last completed and brought to Paris for Napoleon's approval. This was slow in coming. The then Minister of the Interior, the Count of Montalivet,[12] tried several times to retrieve from Napoleon the preliminary printed copy which he had constantly kept on his desk. But each time, even though he was reading something else, the Emperor silently retained Fourier's volume by placing his hand on it. At last he called Fourier to an interview and returned his copy emended in various places in his own hand to make Fourier's description of the Egyptian campaign conform more closely to his own view of it—something not always in complete accord with the actual facts.[13] After the necessary amendments had been made the work was finally published in 1810. Later, at the time of the Restoration, a new edition came out in which all references to Napoleon had been suppressed.

Fourier's general introduction[14] was essentially a survey of the history of Egypt from Antiquity up to the time of the French expedition. One interesting detail[15] from the general background to this expedition was his reference to the memoir presented to Louis XIV by Leibniz detailing the advantages which would have been derived from the French occupation of Egypt. A manuscript containing this memoir evidently came to the attention of the French commander in Hanover during the French occupation of that town. In the revised version of his Introduction Fourier was at pains to prove that the idea of an invasion of Egypt, and the subsidiary idea of a survey of that country, could not have been suggested to Napoleon from a reading of Leibniz's memoir. In other words, that the notion of the expedition was an original idea with Napoleon. At various places Fourier also makes somewhat fulsome references to Napoleon the 'hero of the expedition', his enthusiasm for the victories of the French forces under his leadership making it difficult for him to account for the final capitulation and the enormous losses suffered in both men and material.

One curious aspect[16] of Fourier's contribution to the *Description of Egypt* was his absolute refusal to be rewarded in any pecuniary way for his labours. Whether he was hoping to be rewarded in some other way—perhaps by an appointment to a position in Paris—is not clear, but in any case this time he stood his ground against Napoleon, refused to yield, and was ultimately 'rewarded' by Napoleon's minute 'granted' against his name on the list of contributors.

In spite of all the pains lavished on its composition, Fourier's preliminary discourse is little more than a *pastiche* written in what appears today as a rather flowery early nineteenth century style. But it struck a sympathetic echo in at least one of Fourier's contemporaries as appears from the following letter to Fourier from Fontanes,[17] Grand Master of the Imperial University.

> I do not doubt, Sir, that the work being prepared on Egypt will be worthy of the savants who are carrying it out, but in waiting for this work I have to tell you that your preliminary discourse by itself alone is a fine monument. You write with the grace of Athens and the wisdom of Egypt. Everything is elegant and grave in your style. It is a long time since I have had anything so good and so solid. I am not flattering you. I am expressing my real opinion and I write to you after a second reading which has given me greater pleasure than the first.
>
> Receive, Sir, all my thanks, and the assurance of my highest regard.[18]

Finally, apart from his contribution to the *Description of Egypt*, and his many administrative and other duties as prefect, Fourier somehow found time and energy during his stay in Grenoble for his major life work on the analytical theory of heat.

By the time of his appointment as Prefect of Isère in 1802 the subject of heat had become one of pressing concern to Fourier. It is not known whether his extreme need of, and sensitivity to, heat was a long-standing characteristic; what is certain is that he never managed to acclimatize himself to the change from Egypt to Isère. Thus in a letter of 1810 to the Minister of the Interior he said:

> The prefect of the department of Isère points out that having changed suddenly from the climate of Egypt to that of the Alps, following the long and distressful siege of Alexandria, he contracted several years ago chronic rheumatic pains which without depriving him of an healthy appearance become more and more serious and threaten him with a grave illness.[19]

In fact, if we are to believe Cousin, Fourier brought back with him to France from Egypt—whose climate he is said always to have regretted—a need for great heat at all times which amounted almost to a disease. Thus he never went out, even in the hottest weather, without his overcoat, and often accompanied by a servant with another coat in reserve. When he finally returned to Paris the excessive warmth of his rooms is said to have hastened his death. In Grenoble, where the winters are far more severe than in Paris, his concern with adequate heating of his rooms must have been all the greater. In short, the question of heat, its loss by propagation in solids and radiation in space, the problem of conserving it—on which Fourier advanced interesting suggestions in his Analytical Theory of Heat—can never have been out of his mind for long.

Whether this peculiar personal interest in heat had anything to do with his theoretical work in the subject must remain a matter of surmise. What is certain is that some early work[20] around 1804–5 on the subject of the propagation of heat had grown by the end of 1807 into a full-scale memoir 'On the Propagation of Heat in Solid Bodies'.[21] This memoir contained essentially the whole of Fourier's Analytical Theory of Heat as published in 1822 apart from the treatment of the diffusion of heat in infinite solids. By 1807 the Prefect of Isère had thus added to his many achievements in the administrative field a contribution of the first order in the rather different field of theoretical physics. Fourier's theory put forward methods for solving two distinct kinds of problems: first, given a steady supply of heat at some point or points of a body, to find the eventual steady distribution of the temperature at all points of the body—the case of a thin bar, heated by a furnace at one end and immersed in air held at a given temperature at its surface, provided the simplest (and the most ancient) example of this type of problem. In the second kind of problem a body was originally heated throughout according to a certain given temperature distribution, and was then allowed to cool in an environment whose temperature was given. For example, a uniform sphere initially everywhere at a given temperature was suddenly plunged in a current of air held constantly at zero temperature, and it was required to find the temperature at every point of the sphere at all subsequent times. The great Earth itself provided another, and far more complex, example of the same kind of problem, and one which had apparently stimulated Fourier in his search for a general theory of the propagation of heat in solid bodies.[22] Both classes of problems were based on a single set of equations governing the movement of heat within solids, and supplemented in every case by special equations, the so-called boundary conditions, governing the flow of heat at the bounding surfaces between the bodies and the surrounding environment.

Fourier read an abstract of his memoir before the First Class of the Institut on 21 December 1807.[23] The commission set up to report on the memoir consisted of Lagrange,[24] Laplace,[25] Monge,[26], and Lacroix.[27] The composition of this commission would seem to have guaranteed a fair hearing for the memoir. None of its members were in any way antagonistic to Fourier and there was no reason for the first two to have altered the high opinion they had formed of him during his time at the École Normale and the École Polytechnique.[28] As a veteran of the Egyptian campaign, and the distinguished 'permanent' secretary of the Cairo Institute, he could also expect special support from Monge who had been the first president and one of the prime movers in the foundation and early organization of the same body, and who had in any case known Fourier previously at the École Polytechnique during the years 1795–7. The first reaction to his memoir came in a review[29] by S. D. Poisson in the *Bulletin of the Philomatic Society* which if not exactly enthusiastic was perfectly correct and fair. But Poisson's review was the only public reference to Fourier's memoir outside the proceedings of the First Class of the Institut and certain references by Fourier himself at a much later date, and in spite of a request by the First Class to the commission to hurry up its work no report ever appeared. In fact, far from receiving the universal acceptance and acclaim it can now be seen to have deserved, the memoir gave rise to a lively, many sided, and at times acrimonious controversy. There were two major criticisms of Fourier's memoir, one on the mathematical side, the other on the physical side, and between them they struck at the very foundation of the whole work. The major criticism on the mathematical side was directed at Fourier's use of trigonometrical expansions, or as it would be termed today, at his use of Fourier series. This criticism was probably first made in 1808, Laplace and Lagrange being the principal persons involved. Nothing has survived of their actual criticisms which in any case could have been made orally during an extended visit to Paris by Fourier in 1808–9 in connection with his Introduction to the *Description of Egypt*. However, Fourier's replies to their criticisms have been preserved in the partly legible drafts of two letters to Laplace[30] and (possibly) Lagrange[31] respectively, together with a mathematical note on the topic under consideration. All these are written with such exemplary clarity—from a logical as opposed to a calligraphic point of view—that their inability to persuade Laplace and Lagrange, especially the latter, provides a good index of the originality of Fourier's views. The tones of the two letters also provide an interesting contrast between the almost brutal directness of the letter to Laplace and the deferential, almost reverential, tone of the letter to Lagrange with its somewhat emotional ending:

> 'I desire, above all, to recommend my work to your attention for other reasons and to remind you of the tokens of benevolence you have given the author. My heart will always guard their memory . . . Excuse, Sir, the length of this letter, and be sure that it is written by one who honours and admires you . . .[32]

Unfortunately Fourier's logic and rhetoric were both lost on Lagrange who continued up to his death to disbelieve at least in the rigour of Fourier's use of trigonometrical expansions.

The second major criticism of Fourier's work was directed against his derivation of the equations of motion of heat in a continuous solid. Biot was here the chief opponent aided and abetted at first by Laplace and later by Poisson. Conceivably this attack might have been avoided if Fourier had taken care to make a graceful reference in his memoir to his undoubted indebtedness to Biot's paper of 1804,[33] with its qualitative description of the process of propagation of heat in a thin bar of which a first incomplete and erroneous mathematical formulation was given in the Draft Paper of 1804–5.[34] There is some reason to believe[35] that Biot was sent a copy of this paper or of an early draft of the 1807 memoir which still contained the erroneous derivation. In any case, in 1809, in the course of a review in the *Mercure de France* of a work by Prévost, Biot referred to 'an analytical difficulty which has up to the moment held up all those who wished to submit the propagation of heat through bodies to calculation'.[36] No doubt there had already been some criticism of Fourier's derivation of the equation of propagation of heat in his 1807 memoir on the score of its incompleteness. But to criticize it thus, even if only by implication, in a public journal was an entirely different matter especially since the whole question was still, as it were, *sub-judice*. Fourier's angry response can be seen in two letters to unknown correspondents:

> To treat with such lack of care one of the most important questions in analytical physics, to rush into publishing in periodical works speculations which are still uncertain, and even erroneous, . . . to make use of public newspapers to foist on, and attribute to, others his own errors, and to predispose others against a work which he dare not attack directly.[37]

These were faults which Fourier found it impossible 'to observe without scorn'. In the same letter he also directed a very sharp attack against Laplace whose method of obtaining an analytical expression for the flux of heat in the case of a heated bar had been praised by Biot in his *Mercure de France* article. Laplace was said to have aided Biot in his 'pretended' discovery of a ridiculous iron bar effect, and to have been the object of Biot's 'servile and calculated flattery' which displayed Laplace as the inventor of an idea to which he could not in fact lay claim. Fourier even went so far as to 'sincerely regret' that Laplace did not realize that he was himself thus supporting an attitude 'so false and so contrary to the progress of the sciences': 'the artifices', he added somewhat tartly, 'that an author adopts to exalt his own reputation beyond that which is reasonable never have lasting success and often involve him in bitter regrets'. Fourier ended this letter by a dramatic gesture of renunciation towards his 1807 memoir. 'I would prefer', he said, 'to lose so just a cause rather than defend it by means of public papers', and he declared his intention of abandoning this 'noble theatre' to those who desired it for a career 'equally worthy'.

The controversy over Fourier's work in heat took a new turn at the beginning of 1810 when the propagation of heat in solid bodies was announced as a subject for the Institut's grand prize in mathematics for the year 1811.[38] Almost total obscurity surrounds the manoeuvrings which finally led to the decision to set this subject for the prize. Fourier himself may have given the first impulse in one[39] of the letters concerning Biot's criticisms where he suggests that the question could be cleared up by setting the subject as a prize memoir. Elsewhere, in some unpublished manuscript notes[40] on the historical background to his work in heat, he suggests that attempts were made to prevent the subject being set for a prize essay on the grounds that no report had yet been made on the 1807 memoir. Presumably the First Class of the Institut was divided on the merits of proposing the subject. The supporters of Biot, of whom Laplace at this stage was probably a member, may have argued that if the subject were set as a prize essay Fourier would inevitably be the winner, and that it would then be impossible to pass over his work as in the case of the memoir by simply failing to make a report. In any event, the subject *was* set and Fourier sent in his memoir. According to Champollion-Figeac[41] he then continued in a state of extreme trepidation till word reached him at Grenoble of the safe arrival of his submission at the secretariat of the Institut.

The commission set up to examine submissions for the prize consisted of Lagrange, Laplace, Malus, Haüy, and Legendre. There was one other candidate apart from Fourier. Fourier's submission consisted of the memoir of 1807 together with new sections on the cooling of infinite solids, and on terrestrial and radiant heat. In spite of these important additions the Prize Essay was still identical with the 1807 memoir as regards its essential contents on both the physical and mathematical sides. The unresolved differences of opinion over the earlier memoir might then have been expected to extend to Fourier's submission for the Prize Essay. Nevertheless the Prize was awarded to Fourier. The Institut might thus have been thought to have set the final seal of its approval on Fourier's work. But while the commission was in no doubt of the superiority of Fourier's submission and of its great originality and interest, it was still not entirely reconciled to its validity in certain vital respects. This ambivalence towards Fourier's essay was clearly expressed in the committee's report:

> This theory contains the true differential equations of the transmission of heat both in the interior of bodies and at their surface; and the novelty of the subject combined with its importance has determined the class to crown this work, in observing, however, that the manner in which the author arrives at these equations is not exempt of difficulties and that his analysis to integrate them still leaves something to be desired on the score of generality and even rigour.[42]

Understandably Fourier read the commissions' report with very mixed feelings. What the commission gave with one hand it took away with the other. All his resentment at what would have seemed to him to be the shabby manoeuvrings of Biot, Laplace (and Poisson) must have welled up again, and he apparently wrote a stiff letter of protest.[43] The letter itself has disappeared but not the diplomatic reply[44] of the permanent secretary, Delambre:[45] the commissioners had full powers in such matters, though Fourier could evidently write to them himself if he desired, or add a supplement to the printed version provided it was made clear that the supplement had been written after the period of the competition. There the matter seems to have rested. The Institut appeared to be in no hurry to publish Fourier's masterpiece with or without supplement, and it was not till after his return to Paris in 1815 that he could get the publication of the Prize Essay under way, and then only after further vigorous prodding of Delambre.

2. The first Restoration

Fourier's life in Isère as prefect, writer, and mathematician was evidently a busy and useful one. Yet in spite of this he was apparently always secretly unhappy at his position in Grenoble.[46] The climate as we have seen, especially that in winter, was not at all to his liking; according to him Isère was the 'native land of rheumatism'.[47] He must also have greatly missed the company of his scientific peers and colleagues of his polytechnic days, men like Lagrange, Monge, and Laplace. Fourier, in fact, was the one major French physical scientist of the period 1800–25 who did not spend the greater part of that time in Paris. We know[48] that his friends in Paris including Monge, Berthollet, and Costaz were well aware of his desire to return there from Grenoble, and they apparently made this known to Bonaparte. But the latter always turned a deaf ear to their suggestions, and the post of Director General of Mines which Fourier would have considered as his 'marshal's baton', and a position which he would have filled with ease and distinction, was given to another.

Champollion-Figeac[49] suspected that the reason for Bonaparte's apparent indifference towards Fourier may have originated in the latter's rather too open support for Kléber's criticism of Napoleon at the time of the latter's return to France from Egypt in 1799. For although Kléber had admired Napoleon as a general he had greatly disliked his political opportunism, and the letters written by him to the Directory after Napoleon's return were filled with blame of the latter's precipitate departure from Egypt. These letters, however, were opened by the First Consul himself.

Whatever the exact reasons for Fourier's 'exile' in Grenoble, as the years slipped by it must have begun to seem to him that he would continue as Prefect of Isère until his retirement. But fate was to give one final, unexpected, twist to his career. After the disastrous Russian campaign, and even more after Leipzig, Fourier could not have been the only one of the army of imperial officials who had begun to wonder what the months ahead held in store for him. Would the Emperor be able to continue in power? If not, who would take his place, and in that case would he himself be able to retain a position which he had loyally occupied for more than ten years under the Consulate and Empire? The answer was to come unexpectedly soon. By January 1814 foreign troops were fighting on French soil again for the first time since 1795, and although Napoleon's masterly campaign of February–March gave a final lustre to his military fame by proving his greatness in adversity, it could not prevent the surrender of Paris to allied troops on 31 March. In the meantime Grenoble was besieged by Austrian forces. One of the generals commanding these forces had served under the officer in command of the defences of the city, General Marchand.[50] The two entered into a friendly correspondence and in due course Marchand learnt of the surrender of Paris and the abdication of Napoleon. A convention was then agreed on and the Austrian forces occupied Grenoble on behalf of Louis XVIII who had since become King of France. Under the new regime Fourier continued provisionally as prefect, his high standing with the different classes of society, especially with the members of the old nobility, contributing greatly to a smooth transfer of power. Although the return of the King was unexpected—it had been largely engineered by Talleyrand—it turned out at first to be reasonably popular. The promise of a constitutional charter to guarantee the rights of Frenchmen under the new regime went some way towards stilling the fears of the more republican members of society, and in any case Napoleon's interminable wars had produced a general, if temporary, indifference to the exact nature of authority provided only it ensured a long and uninterrupted period of peace. Fourier himself, however, was soon faced by an acutely embarrassing situation on learning that Napoleon was to pass through Grenoble on his way to Elba. How was he to treat the Emperor about whom still clung some remnants of former greatness? How would Napoleon react to finding his old servant Fourier still Prefect of Isère? Stripped of his power his anger could still be as terrible as ever. Somewhat maliciously Champollion-Figeac[51] suggested that Fourier should follow the Emperor into exile, a prospect which he did not relish in the least, and which visibly upset him still further. On the day on which Napoleon was due to enter the city all preparations had been made for his stay in the prefecture and Fourier was in a state of extreme upset and despondency. Suddenly a messenger arrived to announce that Napoleon would not pass through Grenoble after all, that instead he was to take the route *du midi* through Bourgoin. Fourier's relief at this news was enormous and he retired for the rest of the day to recover his composure. Later Champollion discovered that Fourier had himself engineered the change of route by warning the prefect at Lyons that it would be dangerous for Napoleon to pass through Grenoble owing to the excited condition of the people in the region.

Some time later Fourier visited Lyons where he had an audience of the Duchesse d'Angoulême in which he made clever use of the term 'legitimacy' at this time much in vogue.[52] Although he was not at first politically acceptable he made a good impression on the courtiers who in turn supported Fourier with the Duchesse and he was confirmed in his position as prefect. Soon after, Fourier's new status as loyal servant of the crown was consummated by a visit of the King's brother, the Count d'Artois, later King Charles X, who thereafter and in spite of the unfortunate happenings of the Hundred Days always retained an excellent opinion of Fourier.

By the beginning of 1815 Fourier's administration in Isère had doubtless settled down again into very much the same grooves as before. True, there were some signs of unrest due to the wild statements of the Ultras—the followers of the Count D'Artois—and of some of the higher clergy who urged the government to return to their rightful owners the noble and clerical lands sold during the Revolution; and J. J. Champollion-Figeac[53] relates how several inhabitants of Grenoble received a proclamation dated 22 February 1815 which played cleverly on these and other complaints of the people under the royal régime and predicted that 1 March at 5 a.m. would see the first act in a new drama. But this was only one of many *canards* and rumours circulating at the time, and no doubt Fourier dismissed it in company with the others. He could not, however, so easily dismiss a letter from the prefect of the neighbouring department of Var dated Fréjus 2 March:

> My dear Sir and Colleague,
>
> I have the honour to inform you that Bonaparte at the head of 1,700 men disembarked yesterday at Gulf Juan, reached Grasse this morning, and according to those soldiers who have been questioned is heading for Lyons by Saint-Vallier, Digne, and Grenoble. No matter how extraordinary this news may seem to you it is entirely true.[54]

3. Flight from Grenoble

Fourier's feelings on receiving this totally unexpected and indeed terrifying note can be imagined. The Emperor, who as First Consul had originally appointed him Prefect of Isère and whose abdication route to Elba he had diverted from its original path through Grenoble—ostensibly in the interests of public order, in reality to avoid the exquisite embarrassment of having to entertain Napoleon in his (Fourier's) continuing capacity as Prefect—the same Napoleon grown terrible again was now retracing his steps from Elba to Paris but this time by the geodesic path through Grenoble, and this time without any possibility of diversion.

Faced not only with a question of personal danger and embarrassment, but one possibly affecting the future of both France and Europe, Fourier acted with commendable dispatch. The letter from the Prefect of Var had reached him at 4.00 p.m. By 7.00 p.m., when he commenced a letter to the Minister of the Interior in Paris, he had not only made up his mind to oppose Napoleon but in collaboration with the mayor of Grenoble, the commanding officer of the garrison, General Marchand, and the Inspector of the local National Guard he had worked out various contingency plans, including the disposition of forces to prevent crowds of seditiously inclined persons from moving on the residences of the principal authorities of the town or seizing public money for the enemy cause.

Having somewhat optimistically assured the Minister that the inhabitants of Grenoble and the surrounding area were firmly behind the King, and having expressed himself confident of the outcome of a trial of strength with Napoleon by reason of the loyalty of the citizens of the neighbourhood and of the soldiers, Fourier concluded:

> I beg your Excellency to transmit to me the instructions you will deem appropriate. Be assured that I will carry them out zealously and faithfully, no motive of fear will turn me from my duty towards King and country. I know personally the audacious enemy who threatens us and I do not doubt that before very long he will send us emissaries . . .[55]

Fourier's letter is minuted as having been completed at 7.00 a.m. on the following morning and we may surmise that he passed a troubled night. In a postscript he informed the Minister of the Interior of letters received from surrounding prefects, and of how the inhabitants of Grenoble who had at first been thrown into confusion by the news of Napoleon's disembarkation had now in great numbers declared against him.

In the afternoon of 5 March Fourier had a proclamation[56] put up in the town containing an official admission of Bonaparte's disembarkation at Gulf Juan, reminding citizens of their duty to the King, and warning those who might be inclined to forget it that they would be 'arrested immediately and severely punished in conformity with the laws of the constitution'. That the views expressed by Fourier in his proclamation were no empty words, but were intended seriously by him at this time, is proved by a letter[57] of the prefect appointed by Bonaparte to replace Fourier which describes the latter's 'frenzied anger' at the treasonable activities of Bonaparte's supporters in Grenoble. Fourier, it appears, had even threatened to have them executed if they helped the Emperor's entry into Grenoble. But in spite of all the genuine efforts of Fourier and other prefects and authorities in the southern part of France Napoleon's progress was irresistible. On the whole he was welcomed by the majority of the population who had grown restive under the increasingly reactionary policy of the King's government. As he passed through the surrounding countryside opposition melted away. There was no overt act against the King's regime, but on the other hand there was no determined support for it. There was no group of citizens, for example, in Grenoble, who stood up for the King with sufficient strength to affect public opinion. By 7 March Napoleon was drawing near Grenoble. The previous day he had had his famous confrontation with soldiers of the 5th Regiment of line. On the sixth there was a dramatic defection from the King when the 7th Regiment of line rode out of Grenoble with their colonel at their head, drew up on the roadway in full view of the city walls, replaced the royal colours by the tricolour, and rode off to join Napoleon.

On 7 March Fourier had an official proclamation published announcing the imminent arrival at Lyons of the King's brother, the Count d'Artois, to take over command of a royalist army to oppose Napoleon. It also reminded officials and all others under Fourier's administration of the 'sentiments of fidelity which should bind them to the King'.[58] In retrospect this looks like one last despairing effort on Fourier's part to rally the inhabitants of Grenoble and the still unoccupied part of Isère behind the King's government. In fact it was still at this stage uncertain whether or not Grenoble would fall without a fight. If it had stood out against Napoleon his bid to regain power might well have failed. But in the event he bluffed his way into the town without a shot being fired.[59] As he entered triumphantly at one gate General Marchand and Fourier left the town by other gates, Fourier on the road to Lyons, and Marchand on the road to Cambéry. Before leaving Fourier had prudently taken out an insurance policy against possible future developments by preparing a room for Napoleon in the prefect's residence.[60] Besides fresh linen on the beds etc., he left a letter to Napoleon in which he managed to express both his feelings of obligation towards the King and his wish not to offend his old master. He likewise left a letter for General Bertrand[61] whom he had known in Egypt.

Fourier left Grenoble on the night of 7 March. By the twelfth he was in Lyons. When he left Grenoble he was still Prefect of Isère under the King. When he reached Lyons he had become Prefect of the Rhône under Bonaparte. Accounts differ somewhat as to exactly how this unexpected metamorphosis took place. According to Cousin[62] it was Napoleon who sought out Fourier. According to Arago,[63] Fourier proceeded straight to Lyons where he had a stormy interview with the King's brother, the Count d'Artois, who ordered him back to Grenoble. According to Champollion-Figeac[64] and Fourier[65] himself it appears that Fourier was on the road to Lyons when he received a dispatch from that town which caused him to halt. The dispatch in question, dated Lyons 8 March and from the then Prefect of the Rhône the Count Chabrol, has been preserved[66] and bears out the account of Fourier and Champollion-Figeac.

If we are to believe Fourier[67] he then waited where he was on the road until the arrival of the Count De Polignac,[68] the *aide de camp* of the Count d'Artois. Sometime latter he turned towards Grenoble on the basis—as he later claimed—of the instructions in Chabrol's dispatch. But his actual instructions in that dispatch were to move towards Lyons or Grenoble 'depending on developments', the intention evidently being that if things were going badly for the royal cause he should retire to Lyons, whereas if the royal cause was in the ascendant he should advance to Grenoble. By the evening of 8 March Napoleon was sweeping towards Lyons with an ever increasing army. It must have been obvious to anyone who knew the comparative merits of Napoleon and the Count d'Artois in the field, and who was aware of the feeling of the majority of the people towards the royal regime, that the King's cause was lost in that part of France, and that even if the Count d'Artois were to stand and fight he would be brushed aside by Napoleon. The Count had in fact no intention of risking a battle with Napoleon and quickly retired from Lyons. According to Champollion-Figeac[69] Fourier learnt of this from a courier. Although Fourier understandably makes no mention of it, circumstantial evidence points strongly towards this being the real reason for him turning back towards Grenoble. According to Fourier[70] he was soon surrounded by a group of soldiers and brought before the Emperor at Bourgoin where he was received with great hostility because of his known attempts to cut communications across the Rhône. Helpless and under the most extreme duress he finally gave in to Napoleon's plans and accepted the prefecture of the Rhône. Champollion-Figeac's account[71] is somewhat different and rather more plausible than Fourier's: according to him Fourier proceeded to Cessieux where he spent the night of 8 March. He also sent a message to Champollion-Figeac in Grenoble, no doubt to sound out Napoleon. Napoleon had at first been enraged by Fourier's failure to greet him on his entry to Grenoble and by what he regarded as Fourier's ungrateful conduct. An order issued at Grenoble on 9 March bears witness to the Emperor's displeasure:

> The Prefect of the department of Isère is suspended from his office. He is required to have evacuated the territory of the 7th military division within the space of 5 days on pain of being arrested and treated as an enemy of the nation.[72]

Thereupon Figeac, who is the hero of his own account, set to work to mollify Napoleon's attitude to Fourier. He first made sure that a copy of Fourier's 'Historical Introduction' to the *Description of Egypt* was prominently displayed on Napoleon's visit to the municipal library. Then he drew the Emperor's attention to the letter written by Fourier to him before his departure from Grenoble, for Napoleon had stayed not in the prefecture but in a small hotel and the letter had not been forwarded. Napoleon was thus at first unaware of Fourier's thoughtful action. Gradually his anger cooled until finally he told General Bertrand to find Fourier and bring him to him. Immediately on hearing this Champollion-Figeac sent the good news to Fourier who was sheltering at a safe distance from the route which Napoleon would take between Grenoble and Lyons. On receiving the all-clear from Figeac Fourier then proceeded to Bourgoin where he was presented to Napoleon. The latter's reception was in no way hostile and the next day Fourier heard from Bertrand that he had been made Prefect of the Rhône.

4. Prefect of the Rhône

Bonaparte's order appointing Fourier Prefect of the Rhône was dated 12 March, and he was installed at Lyons the same day in a ceremony carefully documented[73] by the Secretary General of the prefecture, one of those indestructible bureaucrats whose continued devotion to duty and administrative punctilio provided so powerful an element of continuity during the kaleidoscopic dynastic changes of the 1st and 2nd Restorations. Fourier later claimed[74] that he was full of uncertainty as to whether or not he should exercise the powers thus thrust upon him by the 'usurper' Napoleon. If he did he would be carrying out the orders of 'an enemy authority', if he did not he would be unable to use his considerable powers as prefect to intervene on behalf of innocent citizens threatened by the pro-Bonaparte party. In the event he decided—once again according to his own account—to appeal to the King for instructions, and for this purpose had dispatched from Lyons on 15 March an entirely trustworthy (but unnamed) messenger whom he had called from Grenoble for the purpose. But this messenger was turned back at Fontainebleau before reaching Paris and returned without instructions to Fourier at Lyons on 23 March. Nothing then remained for Fourier but 'to retire quietly (from his position as prefect), having stopped the first effects of personal vengeance and political fanaticism'. Unfortunately for this account, however, there is a considerable body of documentary evidence which points to a prefect who was by no means an unwilling servant of the new Imperial Government up to his 'quiet' retirement sometime after 17 May. Thus on 30 March 1815 he is writing[75] to the newly appointed Minister of the Interior, Lazare Carnot,[76] to congratulate him on his appointment—'a new proof of the clear view of his majesty'—and to inform him that the inhabitants of the Rhône had rallied to Bonaparte apart from some partisans of the previous government who were 'few in number and without influence'. Far from waiting on instructions from Paris Fourier had anticipated them by taking all necessary steps to 'strengthen public opinion still capable of being led astray by some new lies spread intentionally'. The curious analogy between Fourier's actions as Prefect of Isère at the end of the first reign of Louis XVIII, and his actions as Prefect of the Rhône at the beginning of Bonaparte's second reign would not have passed unnoticed by anyone who examined the documents in question in the Archives of the Ministry of the Interior on the occasion of Fourier's first application for a state pension in December 1815.

On 1 May Fourier is writing[77] to the sub-prefects of his department instructing them about arrangements for voting in accordance with an Imperial Decree relating to the so-called '*Acte Additionel*'[78] to the imperial constitution. This letter is a model of bureaucratic thoughtfulness in which nothing is overlooked down to the smallest details and Fourier had probably little to do with it apart from signing his name. This he does as Count Fourier, a shortlived title conferred on him by imperial decree which he understandably did not employ after the Hundred Days, reverting instead to his old title of Baron. On 6 May he is writing[79] a much more compromising letter to the Minister of War (with copies to the Minister of Police and the Minister of the Interior) on the question of recruitment for the *grande armée*. From this letter it is evident that part of the prefecture was being used as a recruiting office:

> The recruiting officers occupy one of the offices of the prefecture, and I have them supplied with the material necessary for their writing. There are already some white forms left by the former recruiting captains, but they will not be enough to provide for duplicate copies: I am having others printed . . .

The decree relieving Fourier of his position as prefect was dated Paris 17 May.[80] But it would seem to have been somewhat slow in reaching him since on 22 May we find him writing[81] as prefect to the Mayor of Lyons concerning the surveillance of two persons 'suspected of having been the principal instigators of the seditious movements which appeared in the Department of Hérault'.

The evidence presented so far points to a Fourier who was perfectly willing to carry out all reasonable administrative requests, even those concerned with recruitment for the Imperial armies or the surveillance of political suspects. Nevertheless at the same time there is no reason to doubt his own claim[82] to have lost no opportunity of reducing as far as possible all injustice and suffering associated with the change of regime following Napoleon's return from Elba. Fourier himself supplied an example of this in one of his applications for a pension after Waterloo in the form of a written testimonial of a certain Count of Saint Vallier who was freed from prison as a result of a letter written by Fourier on his behalf to the local military commander Marshal Suchet:

> Paris 27 October 1815.
>
> Some of the facts contained in the memoir of M. the Baron Fourier, former prefect of Isère, were already known to me, and I find that M. Fourier relates them with too much modesty since he makes no mention of the esteem and gratitude of those formerly under his administration which he has merited in so many ways.
>
> I cannot pass over in silence a matter concerning myself which happened sometime between the months of March and July last. I was arrested in my house in the month of April of that year and transferred to Lyons with the Mayor and the commandant of the National Guard of the town of Saint Vallier by order of General Grouchy to appear before General Corbineau, special commissioner of Bonaparte. Some considerable time after the said General Corbineau

had left, I presented myself to Marshal Suchet, commandant of the army, to demand from him our liberty. This Marshal appeared astonished and pained with such an arbitrary act executed without any apparent motive; but he added that as all three of us had been arrested by an authority other than his own he could not free us unless this were demanded by the Prefect of Lyons who would go bail for us. The prefect was then M. Fourier, who did not hesitate to write a very strong letter to Marshal Suchet to obtain our release which he took all necessary steps to ensure, and which did ensue, and it is to M. Fourier that three citizens arbitrarily and unjustly arrested owed their liberty which would long have been in jeopardy without him.[83]

Accounts differ on the reasons for Fourier being relieved of his position as Prefect of the Rhône. According to Cousin[84] it was due to Fourier's unwillingness to comply with certain harsh orders emanating from Carnot in Paris. But Champollion-Figeac,[85] who is very circumstantial and quotes verbatim at considerable length from Fourier and the other persons concerned, claims that his resignation was due not to orders emanating from Carnot but from a certain Count Maret,[86] one of a number of extraordinary commissioners sent by Napoleon throughout France to ensure compliance with his commands. In particular Fourier is said by Champollion-Figeac to have refused to carry out a purge of certain administrators including some in his own prefecture who were suspected of royalist sympathies. There seems however to be no extant documentary evidence bearing on this question and in a letter[87] of 15 May to Count Maret we find him expressing *agreement* with certain measures proposed to him by Maret.

Whatever the reasons for Fourier's removal from the prefecture of the Rhône they do not seem to have entirely destroyed his credit with Carnot or Napoleon, for on 10 June Napoleon decreed as follows:

At Imperial Palace of Elysée
10 June 1815.

Napoleon, Emperor of the French, on the report of our Minister of the Interior, we have decreed as follows:—

1. There is granted from 1st July, 1815 a retirement pension of 6,000 francs to each of the following:
   Fourier ex-Prefect of Isère and of the Rhône.
2. These pensions will be inscribed in the great book of public debt. They cannot under any pretext be added to any other pensions or salaries paid by the state in such a manner as to exceed the level fixed by the present decree.[88]

However by 1 July, the day on which the first payment was due, Napoleon had been defeated, the King had returned, and Fourier never touched a franc of the pension. It was to be at least six years before he received any money in the way of pension for all his many educational and administrative services to the State.

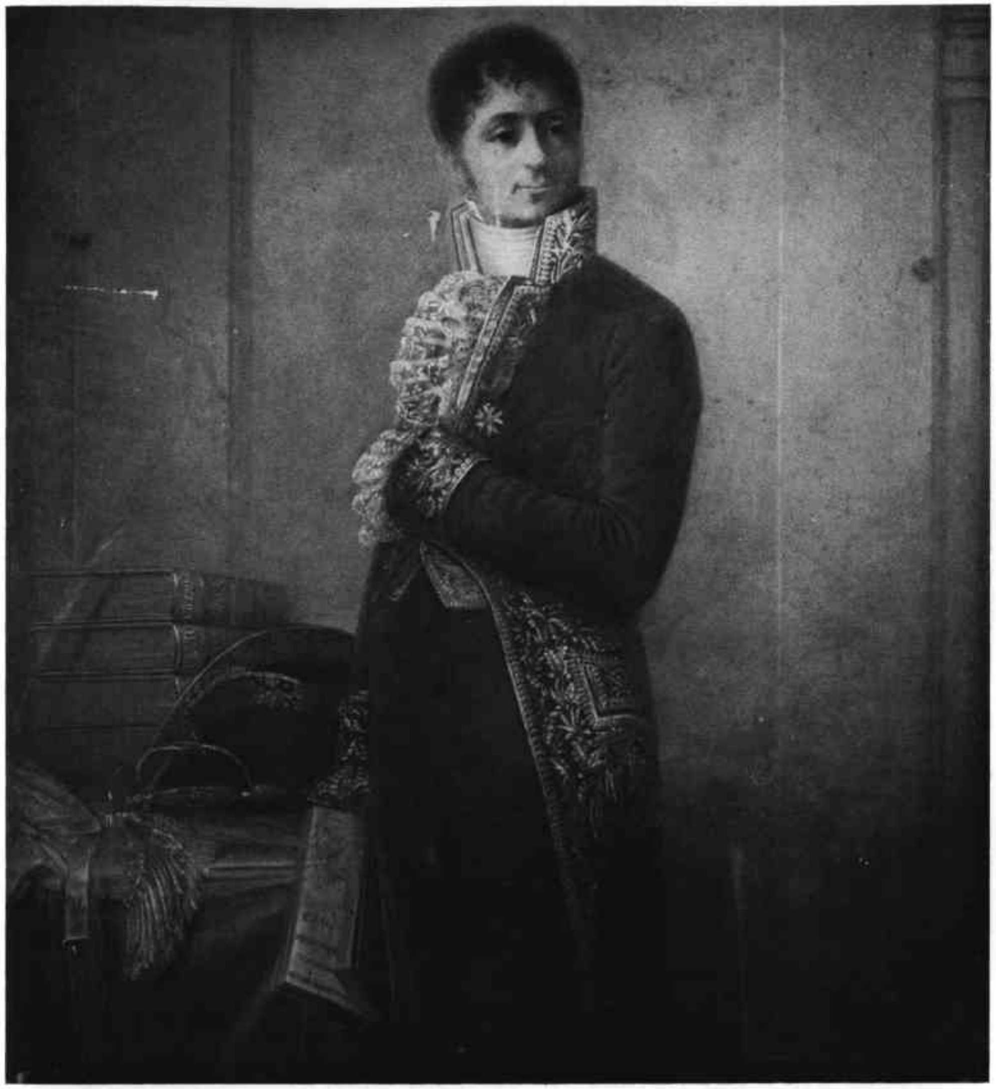
Notes

1. Champollion-Figeac, J. F. Called Champollion *le Jeune*. French Egyptologist, 1790–1832. While Professor of History at Grenoble (1812–15, 1818–21) he prepared himself for his epoch-making work on the decipherment of Egyptian hieroglyphics announced in his *Lettre à M. Dacier* of 1822. The extent if any of Champollion's debt to the earlier work of Thomas Young on the Rosetta Stone has never been established. Champollion was made keeper of the Egyptian department of the Louvre in 1826. In 1831 he became professor at the Collège de France.
2. Arago, (1), p. 329.
3. Champollion-Figeac, J. J., p. 26.
4. Ibid., p. 28.
5. This somwhat dull and uninspiring piece is reproduced in Champollion-Figeac, J. J., pp. 333–7.
6. His personal interest in this subject dated at least from his years in Egypt, but now there was a powerful additional reason for collecting statistics relating to the department of Isère as a result of the insatiable appetite of the Ministry of the Interior for such information. At this time (1804) there was no official almanac and an administrative annual was not to appear till 1809. Fourier therefore addressed himself to various savants of the region to undertake the work and supply him with material. He also, as we have seen, requested the Society of Arts and Sciences of Grenoble to make statistics of the region the subject of one of their prizes. But the response to his requests were disappointing, and having discovered that a certain Berriat-Saint-Prix had written a statistical account which the Society judged to be very exact and interesting he asked for a copy. The learned Professor of Law, however, was even more meticulous than Fourier in matters of accuracy, and kept putting off the day of sending Fourier his collection. In desperation Fourier asked a certain Perrin Dulac to complete a statistical survey which he, Fourier, had himself begun. On 10 June 1806 Fourier was at last able to inform the Minister of the dispatch of the first volume of Perrin Dulac's work. But it turned out that Fourier had either not read, or—as he himself claimed—had not received the detailed instructions from the minister regarding this statistical survey. It should in fact have been in manuscript and not in printed form. Fourier hastened to apologize for this error. The relevant order had not reached him. If it had he would have conformed to it 'scrupulously'. In fact although Fourier had had the statistical survey printed he had not had it published though his letter may have given this impression to the Minister. But as soon as he was aware of the details of the missing order he had given rigorous orders himself to see that the work should not be published, and he intended to produce a statistical account of his own on the exact lines laid down in the ministerial order. As for the second volume of Perrin Dulac's work, when Fourier examined it he found many errors. He complained of these to the author and asked the inexorable Berriat-Saint-Prix to examine the work. The latter found many more errors which he detailed in full in a note to Fourier. Fourier then took over the whole printing of both works at his own expense and had them suppressed. In the event the minister never received the completed statistical memoir on Isère. As an experienced administrator of long standing Fourier may simply have played for time until the attention of the Minister was occupied elsewhere. One

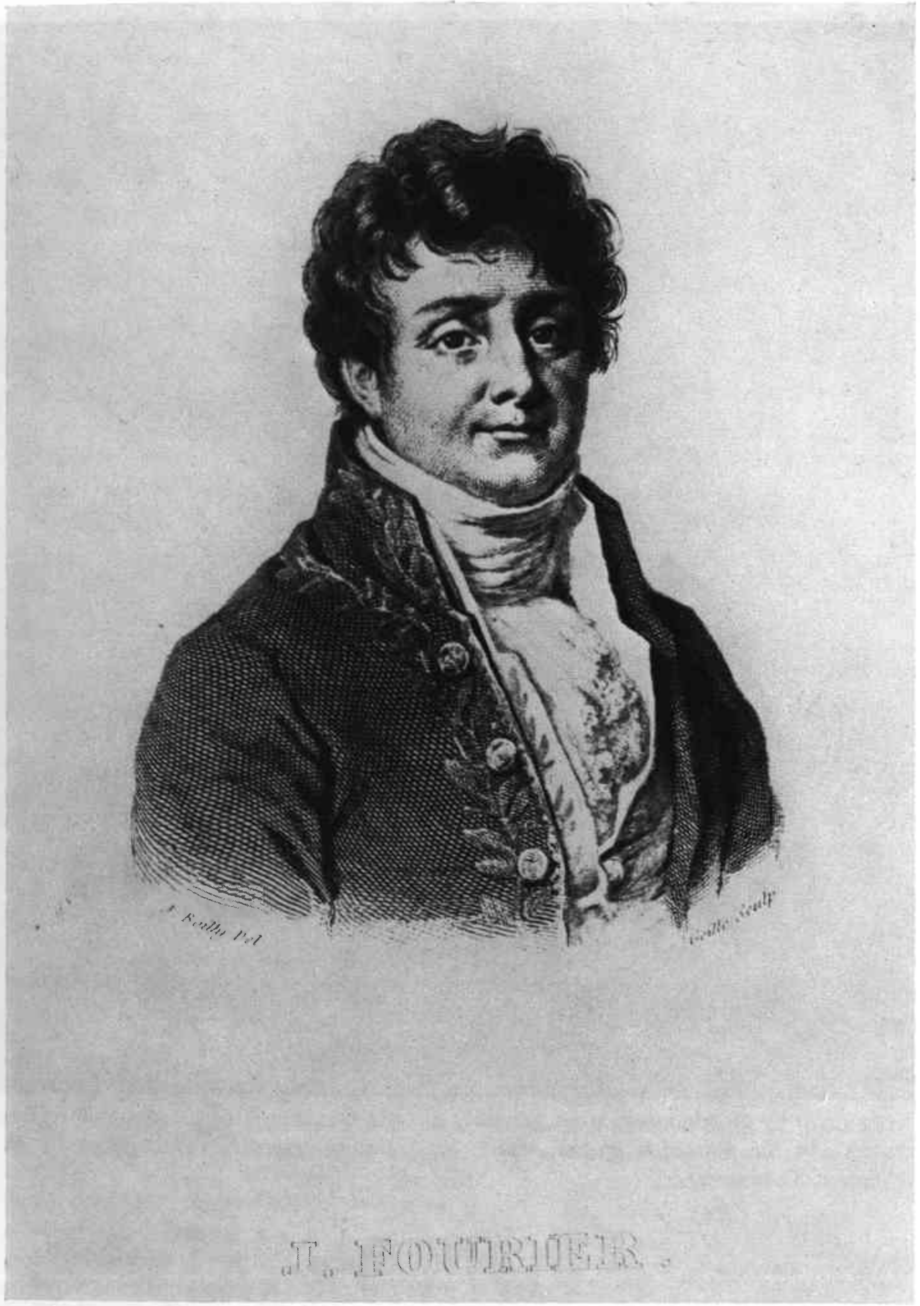
unexpected outcome of the suppression of the edition of Perrin Dulac's work was to make the book itself an excessively rare collector's piece, only four examples being known to Champollion-Figeac (Champollion-Figeac, A. L. (2), pp. 323–8).

7. Reproduced in Champollion-Figeac, J. J., pp. 73–4.
8. Ibid., p. 75.
9. As appears in a letter from Berthollet to Fourier preserved in Fourier Dossier AN. But Fourier was apparently unable to accept and the position as editor was taken by Jomard.
10. See Champollion-Figeac, J. J., pp. 76–81.
11. The château of Beauregard, where Fourier guarded his solitude jealously. But exceptions were occasionally made including a certain Mme Lallier, wife of the chief engineer of bridges and roads in Isère, who visited Fourier on several occasions to paint his portrait. Unfortunately this 'departmental masterpiece', as A. L. Champollion-Figeac somewhat maliciously terms it, seems to have disappeared. Fourier had already had his portrait painted in Paris by Girodet. The portrait, which still existed in the study of a M. Storelli at the time of composition of A. L. Champollion-Figeac's *Chroniques Dauphinoises*, was said to have been one of the masterpieces of the French school.
12. Montalivet, J. P. B., Comte de (1766–1823). Counsellor at *Parlement* of Grenoble. He became acquainted with Bonaparte and was successively appointed prefect, director of *Ponts et Chaussées* (1806) and Minister of the Interior (1809). During the Hundred Days he was intendant general of the Crown.
13. This account is taken from Champollion-Figeac, J. J., p. 82.
14. The text of the first version submitted to Napoleon is reproduced in Champollion-Figeac, J. J., pp. 88–172.
15. Ibid., p. 89.
16. Ibid., p. 84.
17. Fontanes, Louis Marquis de (1757–1821). He published some early poems and a French translation of Pope's *Essay on Man*. At first he embraced the Revolution but his courageous protest against the bloody acts of Collot d'Herbois and Fouché in Lyon obliged him to go into hiding. He emerged after 9 Thermidor and became a member of the Institut and Professor at the École Centrale in Paris. He was proscribed again on 18 Fructidor and lived for a while in London where he became friendly with Chateaubriand. He returned to Paris after 18 Brumaire and by his writings in the *Mercure de France* became the leading opponent of the *Idéologues* of the *Décade Philosophique*. He promoted the establishment of the Empire and gained the favour of Bonaparte. He was appointed Grand Master of the Imperial University in 1808 and Senator in 1810. Under Louis XVIII he was made a member of the Privy Council and a Marquis. He was official orator of the Legislative Corps and Senate under Napoleon, and of the Chamber of Peers under Louis XVIII. Nevertheless he had a mind of his own, was not afraid to oppose Bonaparte on occasion, and was one of the judges who refused to vote for the death of Marshal Ney (*Bio. Gen.*; *Gde. Encycl.*).
18. Ibid., p. 85.
19. Letonnelier, p. 136.
20. Preserved in the Draft Paper.
21. 1807 memoir.
22. Thus in his 'Memoir sur les Températures du Globe Terrestre' (*Œuvres*, **2**, pp. 97–125) he states 'The question of terrestrial temperatures always seemed to me one of the most important objects of cosmological studies, and I had it principally in mind in establishing the mathematical theory of heat.' (op. cit., p. 114).
23. This is the date written on the text of the memoir itself by Delambre, then permanent secretary (mathematics) to the First Class of the Institut. It is also given in *Proc. Verb.* 3, p. 632.
24. See below Letter I, n. 12, Appendix, p. 247.
25. See below Letter VI, n. 10, Appendix, p. 264.
26. See below Letter III, n. 3, Appendix, p. 253.
27. See below Letter X, n. 4, Appendix, p. 288.
28. In his letter (VII) to Bonard, Fourier had said that he was on very good terms with these two mathematicians.
29. Poisson (2).
30. See below Letter XX, Appendix, p. 316.
31. See below Letter XXI, Appendix, p. 318.
32. Ibid., p. 320.
33. Biot (1).
34. Draft Paper, fol. 124.
35. See below Letter XXI Appendix, p. 318.
36. Biot (2), p. 336.
37. See below Letter XVII, Appendix, p. 302.
38. There appears to be no trace in the *Procès Verbaux* of the decision to set the subject of propagation of heat in solid bodies as a prize essay.
39. See below Letter XVIII, Appendix, p. 306.
40. Historical Notes.
41. Champollion-Figeac, J. J., p. 45.
42. Quoted in *Œuvres*, **1**, p. vii.
43. According to Champollion-Figeac, J. J., p. 47, n. 1.
44. *Bib. Nat.* MS. ff. 22529, fol. 119.
45. Delambre, Jean Baptiste (1749–1822). He acquired early a passion for study which was first directed to history and literature. Later his interest turned to mathematics and astronomy and he became the assistant of the astronomer Lalande. He carried off prizes at the Académie des Sciences in 1790 and 1792 for his tables of Uranus and the satellites of Jupiter. In 1792 he was elected to the old Académie des Sciences and in 1795 to the First Class of the Institut and the Bureau des Longitudes. In 1803 he became Permanent Mathematical Secretary to the Institut. He succeeded Lalande at the Collège de France in 1807 and was appointed treasurer of the Imperial University in 1808. His most important works were his *Astronomie théorique et pratique* (1814) and his *Histoire de l'Astronomie* (six volumes: 1817 to 1827) (*Bio. Gen.*; *Gde. Encycl.*).
46. Champollion-Figeac, J. J., p. 30.
47. Letonnelier, p. 136.
48. Champollion-Figeac, J. J., p. 34.
49. Ibid., p. 31. Crosland, p. 60, gives an interesting example of another scientist, Prony, who incurred Napoleon's displeasure, this time by refusing to join in the Egyptian campaign, and who thereafter was passed over for any honours during the whole of the Napoleonic regime.
50. See below Letter XXVII, n. 2, Appendix, p. 330.
51. Recounted in Champollion-Figeac, J. J., p. 37.

52. Ibid., p. 37.
53. Ibid., p. 182.
54. Ibid., p. 187.
55. Ibid., p. 192.
56. Ibid., p. 196.
57. Fourier Dossier AN: item 16 of appendix to Letter of 20 Nov. 1815.
58. Copies of this proclamation are found in the Fourier Dossier AN.
59. Arago, (1), p. 356.
60. Champollion-Figeac, J. J. p. 207.
61. Bertrand, Henri Gratien, Count (1773–1844). He took part in the Egyptian campaign being wounded at Aboukir. He was made *aide de camp* by Napoleon after his brilliant conduct at Austerlitz. Thereafter he accompanied Napoleon on all his campaigns, saving the French army after Leipzig. He became grand marshal of the Imperial Palace, and took part in Napoleon's campaign of February–March 1814. He was present at Waterloo, and afterwards refused to leave Napoleon accompanying him to St. Helena where he stayed till the Emperor's death in 1821. Condemned to death *in absentia* in 1816, he was later pardoned by Louis XVIII and restored to his rank. After 1830 Bertrand became a deputy and constantly defended the liberty of the press. In 1840 he was entrusted by Louis Philippe with bringing back Napoleon's remains to France (*Bio. Gen.; Gde. Encycl.*).
62. Cousin, p. 35.
63. Arago (1), p. 357.
64. Champollion-Figeac, J. J., p. 210.
65. Fourier Dossier AN: supplement to letter of 20 November 1815.
66. Fourier Dossier AN: item 15 of appendix to letter of 20 November 1815.
67. Ibid., note added by Fourier.
68. Probably Comte Armand Jules de Polignac, 1771–1847, brother of the Minister of Charles X.
69. Champollion-Figeac, J. J., p. 210.
70. Fourier Dossier AN: supplement to letter of 20 November 1815.
71. Champollion-Figeac, J. J., p. 210.
72. Fourier Dossier AN: supplement to letter of 20 November 1815.
73. Fourier Dossier AN: *procès-verbal* of Fourier's installation as Prefect of the Rhône.
74. Fourier Dossier AN.
75. See below Letter XXIV, Appendix, p. 324.
76. See below Letter XXIII, n. 1. Appendix, p. 323.
77. See below Letter XXV, Appendix, p. 325.
78. This act, which was in imitation of the charter of Louis XVIII, established a parliament composed of two chambers, a chamber of peers elected by the sovereign, and a chamber of representatives elected by a form of universal suffrage. It was solemnly promulgated in Paris at a *champ de mai* on 1 June 1815.
79. See below Letter XXVI, Appendix, p. 326.
80. Fourier Dossier AN.
81. *Bib. Mun.* Lyon MS. 2274.
82. See below Letter XXVII, Appendix, p. 328.
83. Fourier Dossier AN: item 19 of appendix to letter of 20 November 1815.
84. Cousin, p. 35.



4. A portrait by an unknown artist, possibly Claude Gautherot, of Fourier in prefectorial uniform. (*In the possession of the Musée St. Germain, Auxerre. Photograph by R. G. Phelipeaux of Auxerre*)



5. A portrait of Fourier by Boilly. (*Taken from a copy in the possession of the Archives of the Académie des Sciences*)

85. Champollion-Figeac, J. J., p. 251ff.
86. Possibly J. P. Maret, 1758–1827, brother of the more famous H. N. Maret, Duc de Bassano, Napoleon's *chef de cabinet*.
87. *Bib. Mun.* Lyon, MS. 2273.
88. Fourier Dossier AN.

6

LAST YEARS: RETURN TO PARIS

1. The pension campaign

FOLLOWING his dismissal as Prefect of the Rhône Fourier returned to Paris. There he is said greatly to have enjoyed his new-found freedom from administrative duties, and the opportunity of mingling again with scientific and mathematical colleagues such as Laplace, Monge, and Berthollet. But his pleasure at returning to Paris was to be shortlived; Waterloo and the downfall of Napoleon soon placed him in a desperate financial position. Generous to a fault, and in the habit of living up to the top of his income and beyond, he had little money in his pocket when he came to Paris, and never touched a franc of the annual pension of 6000 francs of which the first instalment was due on July 1. To these pressing financial difficulties was added justified anxiety over the attitude of the King's government to his acceptance of the position of Prefect of the Rhône during the Hundred Days. For a time it seems[1] that he even thought of emigrating to England where he would at least have been free of any political persecutions and could have hoped to make a living by teaching mathematics. Mercifully he was not forced to take this extreme step. As always, there was a friend ready to help, this time in the person of the Count de Chabrol,[2] Prefect of the Seine, a pupil of Fourier's at the École Polytechnique and his companion on the Egyptian campaign. Disregarding any unfavourable reactions from the extreme right, Chabrol had Fourier appointed Director of the Statistical Bureau of the Seine. He thus similtaneously relieved Fourier of any pressing monetary anxieties and ensured that the statistical reports emanating from his department in the next fifteen years or so should be the envy of the world and serve as models of their kind.

Safely ensconced at the Bureau of Statistics of the Department of the Seine in a post for which he was pre-eminently suited on both the practical and theoretical sides,[3] Fourier could give up—no doubt without much regret—the idea of emigrating to England. But there was still much to be done to establish himself firmly in Paris; above all he had to have himself elected to the Académie des Sciences and he had to persuade the government to replace the 'stillborn' pension of 1 June. Fourier lost little time in applying for a pension. On 20 November 1815 he sent a lengthy memorandum[4] to the Ministry of the Interior in which he set out his major services to the State in teaching, in the Egyptian campaign, and as Prefect

of Isère, naturally drawing particular attention to his part in the draining of the swamps of Bourgoin and his contributions to the *Description of Egypt*. If Fourier had confined his activities to teaching and administration this application for a pension would in all probability have been favourably received—provided, of course, his Jacobin activities in the years 1793–4 had not come to light. But his support for Napoleon during the Hundred Days inevitably endangered the success of his application. Aware of this danger himself, he evidently decided it would be best to give a separate justification of his actions in the Hundred Days independent from the original application based on his services to the state in education and administration. This accounts for a supplement[5] to the original memoir dated 22 November 1815 which stresses his efforts to put down sedition in Grenoble prior to Bonaparte's arrival, citing as evidence a letter[6] of his successor at Grenoble, Boissonnett, and the order[7] of Napoleon requiring him to quit the territory of the 7th military division within five days on pain of being treated as an enemy of the State: the rather more doubtful thesis was also advanced that it was in pursuance of the order of the royal authorities that he had turned back to Grenoble and thus fell into the hands of Napoleon; as for his brief tenure of the prefecture of the Rhône, it had preserved the town of Lyons 'from the greatest disasters', while his dismissal had been due to his opposition to the 'unjust and arbitrary' measures required of him.

Fourier's application was duly acknowledged[8] by the Minister of the Interior. Some considerable time then elapsed before he learnt that his application had been refused.[9] Fourier was much too experienced an administrator to accept this rejection as final. He replied immediately with a proper show of feeling in a letter of 28 March 1816; having expressed 'the keenest sorrow' over the Minister of the Interior's reply, Fourier proceeded once again to retail his various services to the state in education, administration, and scholarship. He also pointed out—which was true—that he was the only one who had received no payment for his part in the production of the memoirs on Egypt, and that in the process of draining the swamps of Bourgoin he had been put to considerable personal expenses which had never been repaid.

Referring to his activities during the Hundred Days he suggested that:

> No political motive should efface the memory of so many services from which the State and many generations will receive real and lasting advantages. I realise how out of place it is to speak thus of oneself, and it is as painful to me as it is contrary to good manners thus to recall the outcome of my efforts; but I may be excused if one remembers the absolute obligation under which I find myself to make the most of my services by all means consistent with the truth.[10]

The original of the letter of 28 March is minuted at the top:

> M. Pannellir. Keep this letter. The Prefect of Grenoble at the time of the arrival of Bonaparte should not be surprised not to have a pension.

While the supplementary memorandum dated 8 April 1816 (in which he again gave a separate justification of his conduct during the Hundred Days) is minuted:

> Place these documents in the file of the conduct of M. Fourier during the most disastrous epoch of our history.

Both minutes seem to be in the same hand, probably that of the then Minister of the Interior Vaublanc[11] or possibly the King himself, and evidently neither boded much good for Fourier's application. Not surprisingly the pension had still not been granted by the time of a visit by Fourier to the Minister of the Interior on 9 May 1816. This démarche was likewise unsuccessful though the advent of a new Minister of the Interior, Lainé,[12] delayed a reply to Fourier until June. Lainé then wrote to Fourier as follows:

> Baron Fourier,
>
> You have reminded me of the request which you presented to my predecessor to obtain a retirement pension as former prefect.
>
> His majesty having recently adjourned his decision on this matter I cannot allow myself to resubmit your request to him at present. I regret that this circumstance prevents me from doing anything in your favour.[13]

This letter was evidently not very encouraging and gave Fourier little grounds for hope. He would have been more hopeful if he had known that his good friend the Minister of Marine, Dubouchage[14] had queried whether the King *had* in fact adjourned consideration of Fourier's demand, and that an earlier version[15] of the letter of June from the then Minister of the Interior had been minuted by the King or his first minister the Duc de Richelieu as follows:

> I desire that the Minister sign this letter and that M. Pannellir add a note to know if the new Minister (Lainé) is not disposed to treat M. Fourier more favourably.

Evidently it had been the former, and very reactionary, Minister of the Interior Vaublanc who had chiefly opposed the granting of a pension to Fourier. Nevertheless the pension had still not been awarded by November 1816 as appears from a letter of Lainé to Fourier on the twenty-ninth of that month:

> Baron Fourier,
>
> I have not forgotten what you told me last July and what I myself replied to you then.
>
> I spoke of my desire to obtain for you a pension for all your administrative and literary labours. I am constantly aware of the need for this and I shall eagerly seize any opportunity which may present itself for proposing it (to the King).
>
> I have your memoir before my eyes. The important service which you rendered to the state by the considerable draining operations carried out and completed under your directions is not the kind of service which can remain unrewarded.[16]

This must have raised Fourier's hopes very high. But once again he was to be disappointed and thereafter there is no record of any further demands by Fourier before a letter[17] to Lainé of 10 March 1818 in which he refers to Lainé's encouraging letter of 29 November 1816, to his intervening election to the Académie des Sciences (May 1817), and joins a memorial[18] supporting his request from a deputation of four persons from the department of Isère. Again there was no response, since there is a further application[19] of 9 September 1821 in which Fourier briefly goes over the (now) familiar grounds of his claim for a pension. This time the application was backed up by a letter[20] from Fourier's friend Chabrol the Prefect of the Seine. To Chabrol's letter Lainé's very reactionary successor Corbière[21] did not even deign to reply himself. Instead with calculated coolness he instructed the Director of the Ministry to reply on his behalf:

> The Minister of the Interior has passed to me the letter you have written him in support of Baron Fourier who solicits a retirement pension by reason of services rendered in education and administration. His Excellency, who appreciates the merits and services of this former official, would like to have been able to give you some hope for the success of his demand, but the strict provisions of our legislation on pensions absolutely prevent it. As a necessary condition for obtaining a retirement pension the relevant decree of 13 September 1806 requires 30 years of salaried service, and 60 years of age at the moment of termination of duties. M. the Baron Fourier seems to have fulfilled the first condition, but he had not reached 60 years of age on quitting the administration in 1815. His demand is therefore inadmissible according to the terms of the decree in question. I regret, personally, being unable to advance the interest which you have for him.[22]

No doubt the discouraging message in this letter found its way back to Fourier. It must have seemed to him at this stage that there was no point in making any further applications. The refusal to grant him a pension on the purely technical grounds of his having retired before reaching the age of sixty, especially since that retirement was in the form of a dismissal during the Hundred Days, must have made it clear to him that the then Minister of the Interior was inflexibly opposed to his demand. In fact he was awarded a pension at some subsequent date, but curiously the pension was granted by the Minister of Police for 'important services of information'[23] rendered him by Fourier. The information in question is unspecified and one can only hope that Fourier had not been acting as a police informer, and that the information transmitted by him to the Minister of Police was of a statistical nature which in his position as Director of the Statistics Bureau of the Department of the Seine he would have been in a good position to provide.

2. The Académicien

Apart from the pension campaign, Fourier's other major preoccupation in the first years of his return to Paris was his election to the Académie des Sciences. In April 1816 word reached him of a proposal to elect several new members as 'free *académiciens*',[24] that is as opposed to the ordinary procedure in which election had to await the vacation of a 'chair' through the death of a sitting member. A commission[25] was set up to compile a list of possible candidates for the free positions. When Fourier called on members of this commission some of them were not at home. This gave him a useful excuse to write[26] to the President of the First Class of the Institut with a request to bring before the commission his claims for consideration on the grounds of his contributions to science; 'my attachment to science' he said 'is in truth the only claim which I should advance to win your vote'. Nevertheless he shrewdly added a reference to the prize awarded him by the Institut itself.

Fourier's case was a strong one on purely scientific grounds if only on the score of his Prize Essay of 1811. Moreover, although Lagrange[27] had died, and Monge[28] had been forced out as a supporter of Bonaparte, Laplace[29] still remained very powerful and would doubtless have supported Fourier's candidature. It is probable, too, that Fourier's charm would have had its effect on those members of the election commission whom he had been able to find at home. In the event, however, his election on 27 May 1816 to one of the two free positions was anything but a walkover: at the *séance* of 20 May 1916 he was one of eight candidates shortlisted for the two places of free *académiciens* out of the original list of thirty-four presented to the Académie by its election commission.[30] At the first round of voting at the *séance*[31] of 27 May de Rosily[32] obtained 16 votes, de Cubières[33] 12 and Fourier 11; at the second round de Rosily 20, de Cubières 13 and Fourier 11. On a straight vote between de Rosily and de Cubières the former was elected to one of the free places by 39 votes to 14. At the first round of voting for the second place Fourier obtained 27 votes and de Cubières 18, and Fourier was then elected to the second place at the second round when he obtained 38 votes against de Cubières 17. The Minister of the Interior, Lainé,[34] was informed of Fourier's election the same day by letter from the Permanent Secretary (mathematical sciences) Delambre,[35] with a request that the election be submitted for approval to the King. In more normal times such approval would have been no more than a formality. But the times were by no means normal in May 1816. Admittedly they were more normal than they *had* been in the summer of the previous year when the White Terror had been active again in France, especially in the south and west, and when many former Jacobins, Napoleonists, and other 'non-conformists' had been murdered by gangs of 'royalist' assassins. But as long as the ultra-reactionary Vaublanc[36] continued as Minister of the Interior Fourier's chances of entering the Académie des Sciences were as dim as his chances of obtaining a retirement pension. The replacement of Vaublanc by the comparatively liberal Lainé[37] on 8 May 1816 immediately improved his chances, but the ultra-royalist 'introuvable' chamber of deputies still sat—it was not to be dissolved till the following September—and as long as it continued both the King and his ministers had to moderate whatever inclination they may have had towards a sympathetic treatment of those who had gone over to Napoleon in the Hundred Days, even in a comparatively 'mild' way, as in the case of Fourier. In the event the King refused to confirm Fourier's election to the Académie.[38]

Neither Fourier nor the Académie, however, were prepared to take this rebuff lying down. On 3 June the top brass of the Académie including the president, vice-president and both permanent secretaries wrote[39] to the Minister of the Interior Lainé giving the reasons of the Académie for electing Fourier, at the same time enclosing a letter which had been sent to the Académie in support of Fourier's candidature by the King's own Minister of Marine, Dubouchage:[40]

> M. Fourier, gentleman, author of various mathematical and physical works and of the preliminary discourse of the Description of Egypt desires to be nominated to one of the vacant places in the Royal Académie des Sciences. It is not for me to justify to you the literary claims of M. Fourier, they are known to you, and you are in a better position than I am to appreciate them; but I am glad to render him as administrator (Prefect of the department of Isère) all the justice which he merits: M. Fourier acquired a real claim to the esteem and gratitude of this department by the services which he rendered it as administrator, and by his constant efforts to moderate or modify the harsh dispensations of the tyranny under which France groaned. This conduct has won him the especial gratitude of the families most devoted to the royal cause who found themselves most exposed to oppressive measures; I desire that this justice which I am happy to render to M. Fourier may contribute to ensure him the vote of the Académie.[41]

In his letter[42] of acknowledgement of 4 June, Lainé promised to inform the King of the reasons for Fourier's election and from this time on it appears that he and Dubouchage worked steadily to predispose the King in favour of Fourier's election to the Académie.

Fourier did not have to wait long for his next chance of membership. On 5 April 1817 Rochon,[43] a member of the physics section, died and Fourier again threw his hat into the ring. By 27 April the King's opposition had evidently been overcome as we learn from a letter of that date from Fourier to the *académicien* Huzard:[44]

> I presented myself today at M. Huzard's to have the honour of seeing him and asking him to give me a new proof of his kindness in the next election of the Académie des Sciences. The minister has been good enough to inform the president of the Académie that the obstacle which had annulled the first nomination has been lifted.[45]

Fourier was this time elected by an overwhelming majority, no doubt mainly because he was now competing for a position in the physics section only open to those with certain specific scientific qualifications as opposed to the previous positions of free *académiciens* in which the 'qualifications' were much less restricted. Of the 50 votes cast at the *séance*[46] of 12 May, Fourier obtained 47. The Académie was evidently determined to leave the King and his minister in no doubt of its feelings about the merits of Fourier's candidature, and of its displeasure at the rejection of its original choice of Fourier in the preceding May. The Minister was informed of Fourier's election by letter[47] the same day. This time the election was not opposed by the King. But unintentionally or otherwise he put Fourier on the rack for over a week, not giving his approval until 21 May, Delambre being informed on 23 May.[48]

Much water had flowed under many bridges since November 1789 when the young novice Joseph Fourier had read his first paper to the Académie Royale des Sciences of King Louis XVI. Now some twenty-eight years later, the Revolution, the Consulate, the Empire, the First Restoration, and the Hundred Days having intervened, this same Fourier was at last safely elected to the Académie Royale des Sciences of that unfortunate King's brother Louis XVIII. There can have been few other examples in the history of the Académie des Sciences of so long a gap between the first memoir and the election of so distinguished a *savant* as Fourier. This provides a good measure of the magnitude of the impediment produced by the Revolution in the fulfilment of the scientific ambitions expressed in the postscript to his letter[49] of 22 March 1789 to Bonard: 'Yesterday was my 21st birthday; at that age Newton and Pascal had [already] acquired many claims to immortality'.

Once elected to the Académie Fourier was relieved of any nagging uncertainty as to his scientific standing. Now at last he could devote himself entirely to his true *métier*. The result was a period of intense activity which made the years between his election to the Académie in May 1817 and his election to the position of permanent secretary (mathematical sciences) in November 1822 one of the most scientifically useful in his life. He immediately threw himself wholeheartedly into the life of the Académie, sitting on a large number of commissions set up to examine a variety of matters especially the consideration of memoirs submitted to the Académie. In no fewer than ten cases[50] as reporter, or secretary, Fourier was responsible for drawing up the final report of the commission in question. At the same time he actively pursued his own researches, and during the period in question he submitted a total of eight original memoirs to the Académie, two on statistical[51] topics, two on mathematics,[52] and four on the analytical theory of heat.[53]

In August 1822 Delambre,[54] the permanent secretary of the Académie for the mathematical sciences, died. At the *séance*[55] of 11 November 1822 Fourier was placed on the list of candidates for the vacant position along with Biot[56] and Arago.[57] Fourier seems to have been already quietly confident of the outcome of the contest, for in a letter to Sophie Germain[58] he states:

> I cannot doubt now but that the wish of the greater number of my colleagues will be to choose me and that that one[59] of my opponents who flatters himself the most is very much mistaken. But he has resource to so many artifices that it would be imprudent not to fear him.[60]

As usual Fourier was well briefed on the current state of opinion. Arago withdrew his name at the same *séance* on the grounds that his other occupations would not permit him to serve, and at the election[61] on 18 November Fourier obtained 38 votes against Biot's 10. At the *séance*[62] of 6 January 1823 it was announced that Fourier's election to the position of permanent secretary had been approved by the King.

After he became permanent secretary to the Académie Fourier's life as an *académicien* inevitably changed somewhat. He was now responsible for all the official correspondence of the society on the mathematical side with other learned societies and with individuals of all kinds. He also continued to serve on commissions though he no longer acted as reporter. The last such commission to which he was elected was in May 1830, a few days before his death.[63] He also naturally continued to attend *séances*[64] of the society. He was also responsible for composing a number of *éloges*,[65] including those of Delambre—his predecessor as permanent secretary—and Laplace. He was likewise responsible for producing the annual reports on the state of the mathematical sciences.[66] Finally, in addition to all this activity he somehow found time (as in Isère) to continue with his own private researches in mathematics and physics and during the period

1822–30 he published a number of papers in both pure and applied mathematics.

Fourier's life as a savant was enlivened by a number of fierce controversies with certain of his colleagues. The first and most important of these was a recrudescence of that over the period of 1807–10 concerning the Analytical Theory of Heat. This time his opponents were Biot and Poisson with Laplace acting more as a judge than a participant.

Biot's attack on Fourier's treatment of the problem was contained in a footnote of his *Traité de Physique*[67] in which he claimed that in his 1804 paper he had been the first to 'enunciate and apply' the equation for the steady state distribution of temperature in an iron bar at one end. Fourier had no difficulty in exposing the falsity of this claim in a note[68] in his unpublished *Historical Précis* devoted specially to Biot's misdeeds in which he also took Biot to task, as in 1809, for omitting any reference to the earlier work of Amontons and Lambert—a regrettable departure from an 'invariable usage founded on the most just principles'.

Poisson's criticisms were more serious than Biot's and understandably gave Fourier considerable cause for alarm. For Poisson did not restrict himself to a criticism of Fourier's methods, but attempted to give a treatment of the propagation of heat in solids alternative to that of Fourier, and this at a time, 1815, when Fourier had himself published nothing on the subject. In his first paper,[69] said to have been an abstract of a memoir presented to the Académie des Sciences earlier in the year, Poisson referred specifically to Fourier's Prize Essay of 1811 which he had seen in the Secretariat of the Institut. He admitted that Fourier had found the correct equations of the propagation of heat in solid bodies, and that the solutions given in various particular cases were sound, but, in terms curiously similar to those of the report of the commission on the Prize Essay, he maintained that Fourier's treatment left something to be desired both as regards his method for deriving the equations of propagation and the generality of his solution.

Fourier responded to Poisson's attack by a three-pronged counter attack. In the first place, to safeguard his priority in the subject until the publication of the Analytical Theory of Heat—whose printing had apparently begun by 1816—he had a short paper[70] published in various journals containing brief, non-technical accounts of his own achievements in the subject in the still unpublished Prize Essay of 1811. In the second place, he gave a considered reply to the criticism of Poisson in his *Historical Précis*.[71] This work was apparently intended for publication though it never in fact appeared. It may however have been shown to various colleagues, especially Laplace, with its devastating replies to the criticisms of Biot and Poisson. In the third place, Fourier was fortunate enough to be able to show that an application by Poisson of his method to a particular problem was mathematically unsound. This had nothing to do with the validity of the method itself, but it must have seriously undermined its credibility with Laplace to whom Fourier sent a copy of the paper[72] in which he exposed Poisson's errors.

The covering letter to Laplace is in the soothing tones of Fourier the diplomat and peacemaker:

> I would not permit myself such reflections if they were [directed?] to anyone other than M. Poisson himself, and if they were not submitted to M. Laplace, that is to say a benevolent judge equally inclined to both combatants, and who knows that this great controversy is not in the least serious, and not being public can only have advantages without any awkwardness.[73]

But his true feelings to Poisson (and Biot) were given in another passage:

> Seven or eight years ago M. Biot and M. Poisson expressed themselves in the same way on the subject of my work. Having contested the various results they recognize now that they are exact but they protest that they have invented another method of expounding them and that this method is excellent and the true one. If they had illuminated this branch of physics by important and general views and had greatly perfected the analysis of partial differential equations, if they had established a principal element of the Theory of Heat by fine experiments such as those of the calorimeter, they would have the right to judge my work and to correct it. I would submit with much pleasure and I would recognize that their discussion was a source of precious illumination. But one does not extend the bounds of science by presenting in a form said to be different results which one has not found oneself and, above all, by forestalling the true author in publication.[74]

As usual Fourier had the last word, and although Poisson continued to work on the theory of the propagation of heat, and ultimately published a work on the subject after Fourier's death, there is good reason to believe that henceforward Laplace adopted the role of 'benevolent judge equally inclined to both combatants' which Fourier had so neatly suggested for him in his letter.

Apart from this major controversy with Biot, and more especially Poisson, over the Analytical Theory of Heat, there is evidence for other and less important controversies in which Fourier was involved: one with Cauchy[75] over the question of priority in the discovery of the so-called Fourier transforms, and later controversies with Poisson over certain mathematical questions[76] and some relating to Fourier's treatment of radiant heat.[77] All in all, it was with his old pupil and deputy that Fourier had the most frequent controversies, and in each case Fourier seems to have had the better of him. But this did not affect his high opinion of Poisson's talent. For at the end of the long passage quoted above he says:

> M. Poisson has too much talent to exercise it on the work of others, he wastes it by employing it to discover that which is known. Science waits for, and will obtain from him, discoveries of a greatly superior order.[78]

3. Friendships old and new

Apart from fulfilling his obligations to Science and the Académie, Fourier found time to cultivate old friendships and form new ones both within and without the Académie. Among the list of particular friends given by Mauger appear the names of the *académiciens* Lagrange,[79] Monge,[80] Humboldt,[81] Cuvier,[82] and Navier.[83] Of these Lagrange was doubtless the one most admired by Fourier. Of their relations in the period 1795–8 nothing is known, and thereafter Fourier could only have met Lagrange again on the rare occasions of his visits to Paris in the period 1802 up to Lagrange's death in 1813. Still, we can be sure that in spite of Lagrange's reservations about certain mathematical features of Fourier's Prize Essay of 1811 Fourier would have had no reason to revise the opinion he formed of Lagrange when he first saw him attempting to lecture at the short-lived École Normale of 1795: 'everyone knows that he is an extraordinary man, but it is necessary to have seen him to realise that he is a great man'. As for Monge, who had encouraged Fourier at the time of the submission of his first memoir to the old Académie des Sciences in November 1789, whom Fourier had known in the early years of the École Polytechnique, and in the Cairo Institute where their collaboration as President and Permanent Secretary must have been particularly close, it is to be hoped that Fourier did not desert him when, dismissed from the *Institut* and forbidden to enter his beloved École Polytechnique, he lived out the remaining melancholy years of his life in retirement.

Once he became permanent secretary of the Académie on the mathematical side Fourier must have seen more of Cuvier, his opposite number on the 'physical' side, than any other of his colleagues in the Académie. Their friendship, in fact, would have contributed much to the efficient running of the Académie, and considering Cuvier's enormously powerful position in that body—he had been permanent secretary on the physical side since 1803—it is reasonable to surmise that good relations between the two men had been established prior to Fourier's election as permanent secretary and were a not unimportant factor in that election. In one respect, at least, there was a curious, and possibly significant, similarity between the outlooks of Fourier and Cuvier to their respective sciences: Cuvier believed in a rigid separation between plant and animal species which was the basis of his ineradicable hostility to the 'permissive' evolutionary views of Geoffroy Saint Hilaire, while Fourier believed in an equally rigid and apparently preordained separation between at least two of the most important theories of physical science, that of dynamics and Fourier's own analytical theory of heat.[84]

Although Fourier is said to have lived a rather retired life on his return to Paris after Waterloo, he no doubt made an exception occasionally to attend the Cuvier salon, the most distinguished 'scientific' salon[85] of the day. There he would have met not only non-scientific members such as Henri Bayle (Stendhal) but also fellow *académiciens* such as Geoffroy Saint Hilaire and Humboldt. There is no evidence for the closeness of his friendship with Humboldt. Geoffroy Saint Hilaire he had known in Egypt where, as we have seen,[86] they had not always seen eye to eye.

Apart from Cuvier and Humboldt the only other member of the Académie des Sciences who is known to have been a particular friend of Fourier in his last years was the engineer and applied mathematician Navier to whom Fourier's papers passed on his death. According to Cousin,[87] Navier was one of a number of young men including Dirichlet,[88] Libri,[89] Duhamel,[90] and Pouillet[91] whom Fourier delighted to have around him in his old age. Either Fourier was an exceptionally good judge of mathematical talent—which would not have been surprising—or else Cousin only listed the more distinguished of Fourier's young friends, for all of these four later joined Navier as members of the Académie des Sciences. Dirichlet, elected to one of the coveted positions of foreign associates reserved for the most distinguished non-French scientists and mathematicians, was one of the outstanding pure mathematicians of the first half of the nineteenth century, and made particularly important contributions to the development of some of Fourier's own ideas in pure mathematics.

It is rather striking that among Fourier's particular friends in the Académie des Sciences we find none of the other outstanding French mathematical physicists of the day, Laplace,[92] Poisson,[93] Biot,[94] Arago,[95] Fresnel,[96] and Ampère.[97] If we exclude Ampère on the grounds of his excessive eccentricity—something hardly likely to appeal to the level-headed Fourier any more than to his level-headed friends Cuvier and Humboldt—and Fresnel on the score of his age, and the fact that unlike Navier he happened to be the protégé of Arago rather than Fourier, we are left with the first four. There is every reason to believe that Fourier's relations with Arago were at least correct, if not actually friendly—they had after all a mutual friend in Humboldt—though perhaps Arago was a trifle too revolutionary for the liberal but cautious Fourier of the Second Restoration. There remain Laplace, Poisson, and Biot. Judging by his *éloge* of Laplace's achievement in science and mathematics Fourier was in no doubt of Laplace's genius for the subject. He was not the only person, however, who seems to have had certain reservations about Laplace the man: 'Laplace has done much, he said to Cousin, 'but he would like to have done everything'.[98] A hint of an incipient dislike for Laplace can even be detected as far back as Fourier's letter to Bonard early in the year 1795 in the somewhat malicious account[99] of how Laplace was nominated as a *pupil* at the École Normale and how the great man—always unnecessarily in awe of authority—had accepted the humble position offered him though the government had later 'corrected this administrative error'. The fact that Fourier excused himself at very short notice on the grounds of indisposition[100] from reading the graveside oration required of him as permanent secretary on the mathematical side at Laplace's funeral provides another possible indication of a certain lack of cordiality in his relations with Laplace. Against this, a letter[101] of Laplace to Fourier of 1824 has survived which ends on a very cordial note: 'I embrace you, and renew to you all my feelings of esteem and friendship'. As for Biot and Poisson, the reasons for the rather cool relationship between them and Fourier will be sufficiently evident from what has gone before.[102]

4. The Egyptian Society

The scientists, artists, and literary men who had shared the splendours and miseries of the Egyptian campaign formed a natural fellowship which was renewed by the survivors through their combined work on the *Description of Egypt* on their return to France. Fourier's closest friends among his fellow 'Egyptologists' were said to have been Jomard[103] and Chabrol.[104] Both had been pupils at the École Polytechnique during Fourier's time there, and no doubt Fourier had had a hand in choosing them (as well as Malus and others) as part of the large contingent from the École Polytechnique to the scientific commission. But their real friendship with Fourier would have dated from the campaign itself when Fourier is said to have encouraged Jomard in the study of historical remains which was later to become the ruling passion of his life. Fourier and Chabrol—his other close friend from the Egyptian campaign—had had another experience in common, that of acting as prefect under the Napoleonic régime. But Chabrol had wisely refused to support Napoleon during the Hundred Days, and had made quite certain of not being faced with the kind of agonized decision Fourier was forced to make at Bourgoin by fleeing the country, perhaps a fortunate event from Fourier's point of view since otherwise Chabrol might not have been in a position to come to his rescue in the dark days after Waterloo by appointing him to the direction of the statistical bureau of the Seine.

Among Mauger's list of Fourier's particular friends appears the somewhat unexpected and very colourful figure of the British sea-dog, Admiral Sir Sidney Smith, K.C.B.,[105] a sort of foreign associate of the Egyptian 'Society'. Fourier had, of course, first made Smith's acquaintance under exceptional and distressing circumstances[106] at the time of the attempted return to France of the members of the Commission of Sciences and Arts of the Egyptian campaign. In 1820 Smith migrated to Paris, probably to escape the attention of debt collectors in England, and here he evidently renewed his acquaintance with the Commission, this time under more peaceful and auspicious circumstances. To their credit the members of the Commission did not forget their debt to Smith for saving their collections on the high seas off Alexandria. They showed their gratitude to him in a peculiarly appropriate and charming manner as the following letters[107] relate:

The president and members of the Commission of Egypt to His Excellency the Minister and Secretary of State for the Interior.

Sir,

As the members of the Commission of Sciences and Arts of Egypt were setting sail for France the vessel which carried them was in the power of the British fleet for a time. Their papers and collections were about to be lost to their country, they found themselves in a critical position and their lives were menaced. They would doubtless have succumbed, and the results of their laborious researches would have been destroyed, if a generous Englishman had not come to their aid. Animated by a love of science, Admiral Sir Sidney Smith saved their collections and their persons. They cannot forget the noble devotion of this worthy stranger who was not frightened to compromise himself to assure to their country the results of their labours. As if it were a sacred duty, he religiously looked after the papers of one of us, the perpetual secretary of the Institute of Egypt; and as soon as the commission had returned to France he hastened to send back these papers intact.

We believe, Sir, that this generous conduct merits a signal mark of public gratitude, and we come to propose that your Excellency offers him a token of this in requesting the King that Admiral Sidney Smith should be given a copy of the *Description of Egypt*.

We have the honour to be with respect, Sir, Your Excellency's very obedient servants.

signed: Fourier etc.

26 January 1826

Mr. Admiral,

Forgive my extreme haste for not waiting for a time when I would be free to come and see you to tell you that yesterday, Thursday, the King has signed the order which accords you the *Description of Egypt*. It is less you that I congratulate than my country which has known how to appreciate by this slight mark of public gratitude generous sentiments and magnanimous loyalty.

Please accept the renewed and sincere expression of my regards.

Signed Jomard.

Paris, 1 February 1826

Sir,

I hasten to inform you that by royal order of 25 January his Majesty has been gracious enough to accord you a copy (in fine paper) of the *Description of Egypt*.

I congratulate myself in being able to announce this act of royal munificence, and I beg you to take the matter up with M. Jomard, representative of the government on the Commission of Egypt.

Receive, Sir, the assurance of my distinguished consideration, the Minister, Secretary of State for the Interior.

signed Corbière[108]

Fourier had evidently a special reason for being grateful to Sidney Smith for the safe keeping and prompt return of his mathematical papers, though it is not clear why Smith retained the papers when Fourier and the other members of the Commission had returned to Alexandria. Perhaps Fourier feared for their safety and calculated that they would be safer in the keeping of the British Admiral than in the French ship. If so, it shows that on occasion Fourier was a shrewd judge both of situation and character. Unfortunately, no other evidence of the friendship between Fourier and Smith has survived, or of the conversations they must often have had together in Paris about the Egyptian campaign in which they both played such distinguished though different parts.

Among his circle of close friends Fourier also counted a number of administrators and politicians, men like Lainé[109] too honest to be a good politician and so generous that when he became a minister he had to borrow the uniform of his office; or Augustin Perier,[110] a former pupil of Fourier's at the École Polytechnique, wealthy industrialist and politician, the trusted friend and confidant of Fourier during his stay in Isère as prefect. Also Augustin's younger brother Casimir,[111] the most brilliant French politician of the third decade of the nineteenth century, who by his firm, and on occasion ruthless, policy as Prime Minister probably prevented the outbreak of civil war in the first two critical years of the July Monarchy.

Not all Fourier's friends during his last years in Paris were as grand as Casimir Perier or Admiral Sir Sidney Smith, K.C.B. We learn from Cousin that he had a brother in Paris—probably the same Jean-Baptiste who had written[112] to the Committee of General Security on Fourier's behalf at the time of his imprisonment after the Prairial Days of 1795—who kept a shop, not very successfully it seems,[113] and with whom Fourier always remained very friendly, and whom he helped from time to time, eventually settling a small pension on him. There was also his devoted man-servant Joseph who was entrusted with all his financial affairs, who had followed Fourier from Grenoble and Lyons to Paris, and who was to follow his coffin to the grave. There were still a few old friends left in Auxerre including Roux[114] and Amé,[115] and at least one other young Parisian friend not a mathematician, Victor Cousin,[116] who was eventually to take Fourier's place in the Académie Française. If Cousin's philosophical stock has fallen somewhat since the great days of his extraordinarily popular public lectures in Philosophy in the Sorbonne, nevertheless by any standards he was an exceptionally intelligent and enlightened man who had a lively appreciation of historical accuracy—as his researches into seventeenth century biography show—and the reminiscences and accounts of Fourier which we find in his biographical notes provide many valuable, and often unique, sources of information about various aspects of Fourier's life and his attitudes to science, education, philosophy, and religion.[117]

Cousin relates[118] how he first met Fourier in 1824 at the house of Lainé. He encountered Fourier several times before they became at all friendly. Cousin had just returned from Germany where he had undergone a term of imprisonment on suspicion of being a member of the secret society of Carbonari. On his return to France he continued in disgrace for a time, and not unnaturally Fourier was rather cautious about entering into any sort of intimate relations with such a 'revolutionary' character. But gradually they became more intimate, and when Fourier moved towards the end of his life to a house in the Rue D'Enfer only a short distance from that of Cousin they became much more friendly. Cousin relates how he took care to humour the older man, to be suitably deferential towards him, how Fourier was touched by his attentions, and how gradually he became much freer in his conversation. He delighted to tell stories of his experiences in the Revolution, in Egypt, as Prefect of Grenoble. Understandably, Cousin found particularly interesting any references by Fourier to Bonaparte. Fourier emphasized the benevolence and charm of Bonaparte, and one account he gave Cousin proved so interesting that the latter took an exact note of it. It related to the attitude of Bonaparte towards classical studies:

> Like all great minds Bonaparte passionately loved literature. He had brought to Egypt a collection of literary works entirely disconnected with the object of the expedition and he used to read these in the little leisure which was left to him by the works and cares of command. One day in Cairo as we walked on the banks of the Nile, he took from his pocket a Lucan and began to read to me several passages from it, among others the famous passage on Caesar and Pompey. He greatly admired it, but he did not always understand it very well, and from time to time made mistakes which I corrected for him.[119]

It seems, according to Cousin, that the good Fourier hesitated and lost his way in his early days on the banks of the Nile in trying to translate Lucan to Bonaparte in just the same way as thirty years later when trying to translate Cornelius Nepos and Horace to Cousin in the Luxembourg gardens in Paris. But Bonaparte, who was much less philosophical than Cousin, grew impatient at not advancing more quickly, and after about half an hour he threw down the book on the sand in a rage complaining that Latin was not better taught in his young days. Apparently he envied Garat[120] and others their facility to read Lucan, and he was dumbfounded to learn from Fourier that these gentlemen were almost as embarrassed by the subject as he was himself: 'Is Latin not known any more in France? Ah, one day I'll put that right.' And, as Cousin remarks, he was already dreaming of the restoration of classical studies which played so prominent a part in the structure of the Napoleonic *lycées*.

5. Female relations.

Fourier never married but is said, inevitably, to have been extremely fond of the company of intelligent women. Certainly he was not the only mathematician of the day who courted the friendship of Sophie Germain,[121] one of the select band of female mathematicians of note of which history bears record. A self-taught mathematician of very considerable talent who had held her own in correspondence with Gauss and Lagrange, Sophie was also a person of great charm and vivacity. Fourier's friendship with her extended over the period from at least 1820 until his death, and a considerable number of his letters[122] to her have survived. Most of these are little more than notes dealing with such matters as the reading of Sophie's papers to the Academy, and their interest lies largely in the indication they provide of a certain light-hearted, gallant side to Fourier's physiognomy. For example, on 1 June 1823 he wrote as follows:

> I have the honour to recall myself to the memory and esteem of Mlle Germain. I have for long been very desirous of calling on her, but have been prevented from doing so by certain pressing business.
>
> I send to her enclosed 1° an official letter 2° a ticket for the person who will accompany her. If Mlle Germain does not intend to be present at the *séance*, I beg her to dispose of the ticket as she thinks fit, and if it were necessary I could send one or two more [tickets] but not centre ones.
>
> Alas, I would have much preferred to have been able to retain one of those [centre] tickets myself. I am condemned to speak in public, a great bore, and I am going to appear tomorrow like a feeble light in the midst of a firework display. But I am resigned to bearing invidious comparisons. It has seemed reasonable to me to adopt from the start a grave and simple tone which I shall be able to keep to, and to eschew any pretensions to a success which I would not obtain and which I do not wish for: what I *do* wish for is to retain the esteem and remembrance of Mlle Germain. I beg her to receive the expression of my respect.
>
> Fourier.[123]

In spite of Fourier's evident warm feelings of friendship for Sophie, up to at least 1827 his letters continue to open and close in the same formal sort of way which the French adopt in all but the most intimate correspondence. A note[124] in very broken handwriting addressed to Ch[ère]. S[ophie]. and signed J[osep]h suggests that it required the imminent approach of death itself to effect a relaxation in this iron rule.

A delightfully light and playful letter to Madame Cuvier has also been preserved:

> I make haste to send Madame the Baroness Cuvier several samples of the recent discovery of M. Renard of Vivienne Street. I would like to have included a sample of his prose which is neither less soft nor less clear than his lemonade but I have not been able to find it. It states that the entire contents of a packet should be thrown into a glass of water. The word *entire* is underlined because the packet apparently contains two parts both necessary for the success of the experiment. Mme Renard told the servant that this composition of her husband is made of nectar. Without being entirely of this opinion I have found the liquor agreeable if a little aromatic. She stressed the advantage of the low price, a thing indifferent to the Gods but not to mortals.
>
> I beg Madame Cuvier to allow me to enclose two letters of the celebrated mathematician Monge. I hope later to acquit completely the commission of Mlle Clementine and I shall try to find other pieces worthy of augmenting [her collection ?].
>
> I have the honour of offering to Madame Cuvier the honour of my respect.
>
> Joseph Fourier.
> Paris, Sunday morning.[125]

There is, however, nothing playful about the letter of unknown date from Fourier to a certain Doctor l'Herminier,[126] full of an anxious and delicate concern for a person endowed with the 'rarest and most beautiful qualities' whom Fourier says that he 'tenderly loves':

> Monday evening
> Paris.
>
> Sir and dear colleague in Philosophy,
>
> I received today a letter from the person of whom I spoke to you this morning. She has taken the salutory but unfortunately tardy decision to have recourse to your superior knowledge. She will go to you on the day you will appoint. I thought that Wednesday next at exactly two o'clock or a little earlier. If you would prefer it she could find you at No. 14 Rue Caumartin. She is very keen not to be named or even to be known, and I was able to calm her entirely on this

score because you did not even know her name, and if you were to know it it is very certain that you would be inclined to ignore it entirely even if she herself allowed some questions on that score.

With all my heart I desire that you should receive all details of as many circumstances as possible, and all those that would be useful. In the first conversation that I had with this same person I did not insist on the gravity of the illness, and I only spoke of an analogous principle which could be different though it would produce similar effects. I was frightened in my first interview of producing too strong an impression. However, it is absolutely necessary that she should no longer be in any doubt in this respect, for this illness seems to be deeply rooted and to have become bearable to some extent, so that if there were to remain any uncertainty she might perhaps not make up her mind to the indispensible treatment. In any case, all this is confined to your customary discretion and I congratulate myself that this same person has decided to choose you. She is worthy of all your interest by reason of the rarest and most beautiful qualities. For myself, who love her tenderly, in so much as this entirely unforeseen event may bring to nothing the feelings which I have had for her, I would be most deeply grateful for anything you could do for her and for me.

Receive sir, and dear colleague, the expression of all the feelings of gratitude and attachment which I owe you. I am going to reply tomorrow morning to her letter of yesterday and I will tell her Wednesday at two o'clock at No. 14 Rue Caumartin unless I hear from you to the contrary. I will send my reply to her letter only at two o'clock tomorrow afternoon, Tuesday. If by that time I have received no advice from you it will be expressly understood that she will find you at your home on Wednesday at two o'clock.

Joseph Fourier[127]

Unfortunately, as in the case of so many of Fourier's later letters, this letter is undated, though by the writing it was evidently not written in his very last years. The use of the style *Monsieur* in place of *Citoyen* on the envelope also effectively rules out the possibility of it being written before 1804. It would seem, therefore, most probably to have dated from the early years of Fourier's return to Paris after Waterloo and just conceivably the person concerned could have been Sophie Germain herself who died of cancer at a comparatively early age in 1831.

6. Last years

In his position as permanent secretary of the Académie Fourier led a full and satisfying academic life. He was at the centre of scientific activity in France. He was recognized and respected by his fellow scientists. There was little more for him to ask for. At last he had reached his final and entirely satisfying niche as a man and a scientist. Honours crowded in on him during his last years. He was elected to various foreign scientific societies including the Royal Society of London. In 1826 he was called to the Académie Française in succession to Lemontey.[128] On the death of Laplace in 1827 he was elected president of the *conseil de perfectionnement* of the École Polytechnique. Fate had no more unforeseen twists in store for him. His last years were to be as quiet and happy as the constantly troubled political scene in France and the precarious state of his health would allow. His health had never been good. It would appear that excessive study —presumably around the age of thirteen when he became intensely interested in mathematics—had damaged it and that this was accentuated by the serious illness which he had in the years 1784–5. In coming back from the East to Europe he had also caught rheumatism which was renewed with the slightest cold. He had always had a certain difficulty in breathing—possibly dating from the hours spent in nocturnal study in the 'cupboard' in Auxerre—and at the end of his life this had become so great that he was forced to sleep almost standing up, and when writing or speaking—for fear of bending down and provoking an attack of breathlessness—he put himself into a sort of box which kept his body upright and only allowed his head and his arms to protrude. From the minutes[129] of the Académie des Sciences it appears that he had a serious illness in the year 1825 when a deputation of the Académie was sent to wait on him and bring him its good wishes for a speedy recovery. He recovered from this illness but no doubt afterwards he was much enfeebled.

In a passage at the end of a letter to Auger,[130] permanent secretary of the Académie Française, evidently written some time after his own election to that body in 1826, Fourier wrote:

> Receive the thanks which I have long owed you and the homage of my wishes. You have neither cough nor pulmonary complaints. You are surrounded with a pleasant family, you are happy, be so perpetually. As for me, I already see the other bank where one is healed of life. May I find there Descartes and Berthollet.
>
> Joseph Fourier
> Tuesday morning[131]

But appearances can be deceptive, and when Auger disappeared from his home in January 1829 and was later found drowned in the Seine, Fourier must have recalled this passage in his letter with a pang. The other bank of the river, as it turned out, was closer for Auger than it was for Fourier. Still, he did not have long to wait. The call came suddenly on 16 May 1830 towards 4 o'clock in the afternoon when he had a heart attack from which he died soon afterwards. Dr. Larrey,[132] who looked after him during his short illness, qualified his complaint as a nervous chronic angina complicated by a nervous disease of the pericord and the principal organs of the chest. After his death a subscription was opened to collect money to erect a suitable memorial. The largest contributors (in francs) were Blanchin[133]

(100), Chabrol and Dupuytren[134] (50), and Cuvier, Jomard, Navier and Augustin Perier (30). Sophie Germain, who was herself to die soon afterwards, gave 10 francs, and Biot and Poisson nothing.

Notes

1. Cousin, p. 36.
2. Chabrol, Gilbert Joseph Gaspard, Count de Volvic (1773–1843). During the Terror he was imprisoned with all his family but was freed in 1794. He became a pupil at the École Polytechnique where he opted for *Ponts et Chaussées* and was placed first both in the entrance examination and the final examination for his promotion. He was attached as an engineer to the Egyptian expedition and was a member of the commission of arts and sciences contributing to the *Description of Egypt*. He was named under-prefect at Pontivy where he rapidly planned a new town, and later became Prefect of Montenotte in Italy. He was a very able administrator and was distinguished by the zeal with which he carried out Napoleon's commands especially as regards conscription. Happening to be in Paris at the time of the Malet conspiracy in December 1812 he was appointed Prefect of the Seine by Napoleon in place of Frochot. But in 1814 in company with other members of the municipal council he deserted Napoleon and was one of those who greeted Louis XVIII at the gates of Paris. He was then retained as prefect. On Napoleon's return from Elba he went into hiding. After Waterloo he was reappointed prefect of the Seine and for the next eighteen years devoted himself to the administration of Paris. When certain of his enemies attempted to have him removed from this position King Louis XVIII remarked: 'He has married the town of Paris and I have abolished divorce.' He was retained as prefect by Charles X and retired after the July Revolution in 1830. Chabrol made notable contributions to the improvement of Paris including the building of the Bourse, and of hospitals, abattoirs, and markets. He contributed particularly to the advancement of education in the city. When he was appointed prefect there were 1700 primary school pupils, when he left there were 26 000. He was a great patron of the Arts. He became a member of the Institut in 1820 (*Bio. Gen.; Gde. Encycl.*).
3. He had already had much practical experience of gathering statistical information in both Egypt and Isère.
4. Fourier Dossier AN.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid.
9. Ibid.
10. See below Letter XXVII Appendix, p. 328.

11. See below Letter XXVII, n. 1, Appendix, p. 329.
12. Lainé, Etienne Henri Joachim (1767–1835). A leading advocate in his native town of Bordeaux, he was made a member of the Senate in 1808. Becoming disgusted with the bellicose policy and dictatorial ways of Napoleon he allied himself with the royalists and argued for a just and honourable peace in a celebrated report of a commission of the Legislative Assembly in December 1813. As a result he was publicly accused of treason by Napoleon. He retired to Bordeaux and accepted the provisional title of Prefect of the Gironde from the Duc D'Angoulême in March 1814. Returning to Paris at the First Restoration he was made President of the Chamber of Deputies by Louis XVIII. During the Hundred Days he went into hiding returning after Waterloo as President of the Chamber of Deputies where he fought against the reactionary policy of the ultra-royalists. Appointed Minister of the Interior on 7 May 1816, he played a great part in the ordinances of 5 September 1816 which dissolved the *Chambre 'introuvable'*. A new assembly elected under his influence showed itself willing to end reaction and voted the electoral law of 5 February 1817 in favour of the middle classes. An honest man, he retired from power in December 1818 as poor as when he entered office. Louis XVIII said of him: 'I would never dare to demand anything unjust of my minister.' Recalled to the cabinet as Minister without portfolio in December 1820 he remained in office for one year only. Thereafter he maintained a discreet opposition to the minister Villèle. Under Charles X he opposed the policy of Polignac. He was made a member of the Académie Française by royal ordinance of March 1816. He recognized the July Government but played little part in the chamber of peers under Louis Philippe (*Bio. Gen.*; *Gde. Encycl.*).
13. Fourier Dossier AN.
14. Dubouchage, François Joseph, Viscount de Gratet (1749–1821). A soldier by training he was appointed Inspector General of Artillery but reluctantly accepted the position of Minister of Marine in July 1792. A devoted royalist, on 10 August 1792 he urged the King not to put himself in the hands of the National Assembly, but when the King gave in it was Dubouchage who escorted Marie Antoinette through a hostile crowd to the Assembly. After this he fled from France and did not return before the Directory. He opposed Napoleon and was arrested for a time in 1805 as an agent of the Bourbons. In 1816 he became Minister of Marine again. In this position he did much damage by appointing those who had little to recommend them beyond their royalist zeal. He disapproved of the Ordinance of 5 September 1816 and the moderate policy of which it was an index, and left office in June 1817 to become Minister of State and enter the Chamber of Peers where he usually voted with the ultra-royalists (*Bio. Gen.*; *Gde. Encycl.*).
15. Fourier Dossier AN.
16. Ibid.
17. Ibid.
18. Ibid.
19. Ibid.
20. Ibid.
21. Corbière, J. J. G. P., Comte de (1767–1853). During the Consulate and the Empire he maintained close links with royalist supporters in Brittany. He was a close supporter of the ultra-royalist Villèle in the *Chambre 'introuvable'*.

In December 1816 he became minister of state and president of the royal council of education. When he retired a few months later he had already 'terrorized' the University. On his return to office in December 1821 he showed himself without pity to all those who had proved themselves insufficiently *ultra.* Under Charles X his unpopularity grew daily with that of Villèle. The failure of his notorious 'law of love' by which he had hoped to muzzle the press contributed to the downfall of the Villèle ministry. After the July Revolution he retired to Brittany and succeeded in being forgotten (*Gd. Lar.*).

22. Fourier Dossier AN.
23. Ibid.
24. This new category of membership, which was not explicitly restricted to a particular section, was introduced in the reorganization of the Institut following a royal ordinance of 21 March 1816.
25. *Proc. Verb.*, vol. 6, p. 44. *Séance* of 27 March 1816.
26. See below Letter XXVIII, Appendix, p. 331.
27. See below Letter I, n. 12, Appendix, p. 247.
28. See below Letter III, n. 3, Appendix, p. 253. He was replaced by Cauchy.
29. See below Letter VI, n. 10, Appendix, p. 264.
30. See *Proc. Verb.*, vol. 5, p. 58.
31. Ibid., p. 59.
32. Rosily-Mesros, Count F. E. de (1748–1832). He was elected a free *Académicien* in May 1816. He was a vice-admiral, director of the general depot of the navy. He was also member of the Académie de marine and the Bureau des longitudes.
33. Cubières, S. L. P., Marquis de (1747–1821). He was elected correspondent for the section of Rural Economy and Veterinary Science of the first class of the Institut in 1810 and free *Académicien* in June 1816. He was keeper of external monuments of the palaces of Versailles and the Trianon.
34. See above n. 12.
35. Fourier Dossier AdS. For a note on Delambre see above, chapter 5, n. 45.
36. See above n. 11.
37. See above n. 12.
38. Fourier Dossier AdS. Letter of 29 May 1816 from Lainé to Delambre.
39. Ibid., referred to in Letter of 4 June from Lainé to Delambre.
40. See above n. 14.
41. Fourier Dossier AdS.
42. Ibid.
43. Rochon, A. M. de (1741–1817). Elected to the ancient Académie des Sciences in 1771, and to the experimental physics section of the Institut in 1795. He was a traveller and a marine astronomer.
44. Huzard, J. B. (1755–1838). Elected to the rural economy and veterinary section of the first class of the Institut in 1795. He was Inspector General of veterinary schools and a member of the Académie de médecine and the Société d'agriculture. He was also a well-known bibliophile.
45. *Bib. Inst.* MS. 1976.
46. *Proc. Verb.*, vol. 6, p. 187.
47. Fourier Dossier AdS.
48. Ibid., marginal note in letter of 12 May to Minister of Interior.
49. See below Letter II, Appendix, p. 251.

50. The reports in question will be found in *Proc. Verb.*, vol. 6, pp. 238, 257, 287, 344, 361, 453; ibid., vol. 7, pp. 168, 231, 264, 378.
51. See *Proc. Verb.*, vol. 6, p. 469; ibid., vol, 7, p. 347.
52. See *Proc. Verb.*, vol. 6, p. 329; ibid., vol. 7, p. 270.
53. See *Proc. Verb.*, vol. 6, p. 236; ibid., vol. 7, pp. 52, 88, 274.
54. See above, chapter 5, n. 45.
55. *Proc. Verb.*, vol. 7, p. 386.
56. See below Letter VII, n. 10, Appendix, p. 273.
57. Arago, F. 1786–1853. He was a student at the École Polytechnique and was elected to the first class of the Institut in 1809 in which year he succeeded Monge as professor of analytic geometry at the École Polytechnique. He resigned from this position in 1830 on succeeding Fourier as one of the permanent secretaries of the Académie des Sciences. He entered politics the same year and sat on the extreme left of the Assembly. Arago is remembered for his discovery of the solar chromosphere and for his contributions to electricity and magnetism. He also played a leading part in the promotion of Fresnel's wave theory of light.
58. Germain, Sophie (1776–1831). At the age of thirteen she became inspired with a love of mathematics through reading about the death of Archimedes in Montucla's *Histoire des Mathématiques.* She had to teach herself out of books and against the wishes of her parents. She managed to obtain lecture notes from pupils of various professors at the École Polytechnique and sent these with comments to Lagrange under pretence of being a pupil at the École. Lagrange was full of praise for these comments and when he learned the real author he was surprised but encouraged her. She took up the study of Gauss's *Disquisitiones Arithmeticae*—having learnt Latin for the purpose—and entered into correspondence with Gauss, again under pretence of being a pupil of the École Polytechnique. Once again she received every encouragement. She took up the study of elastic surfaces in which she won a prize at the Institut in 1815. With the encouragement of Fourier and Legendre her researches into the theory of elastic surfaces were published in 1820. She was passionately fond of literature and poetry. Her *Considérations sur l'État des Sciences et des Lettres aux différentes époques de leur culture* was published posthumously in 1833 after her death from cancer in 1831 (*Bio. Gen.*; *Gde. Encycl.*).
59. Obviously referring to J. B. Biot.
60. Reproduced in Stupuy, p. 319.
61. *Proc. Verb.*, vol. 7, p. 394.
62. Ibid., p. 413.
63. Ibid., vol. 9, p. 443. *Séance* of 10 May.
64. One of the most historic of these as regards the physical sciences was that on 26 July 1824 when an account of Sadi Carnot's masterpiece 'Réflexions sur la puissance motrice du feu' was read by the engineer Girard before an audience which included, besides Fourier, Arago, Laplace, Ampère, Fresnel, Poisson, Navier, and Dulong. The failure of any one of these to recognize the value of Carnot's work is a good indication of its originality.
65. Delambre's éloge is given in *Mém. Acad. Roy. Sci.* (2), vol. **4** (Historical section) pp. cciv–ccxxvii, that of Laplace, Ibid., vol. **10**, pp. lxxxi–cii. Fourier also read éloges of Herschel (Ibid., vol. **6**, pp. lxi–lxxxi), Breguet (Ibid., vol. **7**, pp. xcii–cix), and Charles (Ibid., vol. **8**, pp. lxxiii–lxxxviii).

66. These are found in *Mém. Acad. Roy. Sci.* (2nd series) Historical sections: for year 1822, vol. **5**, pp. 231–320; year 1823, vol. **6**, pp. i–lx; year 1824, vol. **7**, pp. l–xci; year 1825, vol. **8**, pp. i–lxxii; year 1826, vol. **9**, pp. i–xcv; year 1827, vol. **10**, pp. i–lxxx; year 1828, vol. **11**, pp. i–lix.
67. Biot (3), p. 669, n. 1.
68. Op. cit., fol. 157 ff.
69. Poisson (3).
70. ‘Théorie de la Chaleur’. *Ann. Chimie Physique*, **3** (1816), 350–75. In the same category were a ‘Note sur la chaleur rayonnant’, Ibid., 4 (1817), 128–145, and ‘sur la température des habitations et sur le mouvement varie de la chaleur dans les prismes rectangulaires’, *Bull. sci. soc. philomatique Paris* (1818) 61–7.
71. Op. cit., especially fol. 161–2.
72. *Bib. Nat.* MS. ff. 22525, fol. 82–84v, 98–98v.
73. Ibid., fol. 91v.
74. Ibid., fol. 98v.
75. See Grattan-Guinness (3), pp. 461–2.
76. Ibid., pp. 463–5. See also Fourier’s paper ‘Note Relative aux Vibrations des Surfaces Élastiques’ (*Œuvres*, **2**, pp. 257–67).
77. See Fourier’s paper ‘Remarques sur la Théorie Mathématique de la Chaleur Rayonnante’ (*Œuvres*, **2**, pp. 427–49).
78. *Bib. Nat.*, MS. ff. 22525, fol. 98v. Poisson had in fact already amply proved his talent if only by his fundamental 1812 paper on Electrostatics, and he was to prove it again by his equally brilliant paper of 1824 on Magnetism.
79. See below Letter I, n. 12, Appendix, p. 247.
80. See below Letter III, n. 3, Appendix, p. 253.
81. Humboldt, Alexander, Baron von (1769–1859). After some geological studies in Freiburg where Werner was one of his teachers, and a period as director of mines in Franconia, he moved to Paris in 1797 to buy the necessary instruments for extended explorations in the tropics. In Paris he made the acquaintance of various savants including Laplace and Berthollet, and formed lasting friendships with Arago and Gay-Lussac. He intended to accompany the French Expedition to Egypt but was diverted by chance and in company with Aimé Bonpland undertook instead a voyage to South America which lasted from 1799–1804. The extraordinarily rich and important results of this expedition were published from 1805–32 in thirty volumes under the title of *Voyage aux Régions Équinoxiales du Nouveau Continent fait en 1799–1804.* The preparations and overseeing of this vast work, to which many other savants contributed besides Humboldt and Bonpland, retained Humboldt in Paris almost continuously from 1808 to 1827 when he at last acceded to the repeated requests of the Prussian government and returned to Berlin. In 1829 he undertook a major voyage to Central Asia at the request of the Czar Nicolas I. Thereafter he devoted his energies to the composition of his *Kosmos* (4 Vol. 1845–58). Although Humboldt’s most important work was in physical geography, of which he was effectively the founder, he also made important contributions to geology and economics (*Bio. Gen.*; *Gde. Encycl.*).
82. Cuvier, Georges Dagobert (1769–1832). Son of a protestant minister he was himself originally destined for the Church. After attending the College of Stuttgart—where he acquired a knowledge of administrative law which later stood him in good stead—he spent six years from 1788–94 as tutor to the children of a Norman nobleman. He occupied his leisure hours in the classification of insects, plants, and animals, especially marine animals of which his increasingly expert knowledge soon led him to recognize many errors in the Linnaean classification. Through the intermediary of Tessier, a member of the ancient Académie des Sciences who had escaped revolutionary persecution by becoming a military surgeon, and who encountered Cuvier by chance in Normandy, the latter entered into correspondence with Geoffroy Saint Hilaire who soon recognized Cuvier’s genius: ‘Come to Paris,’ he wrote, ‘you will play the role of another Linnaeus amongst us, of a second legislator of natural history.’ In 1794 Cuvier came to Paris where he was appointed anatomy assistant in the *Jardin des Plantes*. He was elected to the Académie des Sciences in 1795 before Geoffroy Saint Hilaire had himself become a member. He replaced D’Aubenton at the Collège de France in 1799, and Mertrud at the *Musée d’Histoire Naturelle* in 1802. He was elected Permanent Secretary of the Académie des Sciences for the physical sciences in 1803. He prospered both under Bonaparte and Louis XVIII, the latter appointing him ‘minister of dissident cults’ and chancellor of the university, while under Louis-Philippe he was made a Peer of France. He was elected to the Académie Française in 1818. Cuvier was effectively the creator of comparative anatomy and palaeontology, and thus ultimately contributed powerfully to the establishment of the theory of evolution though he himself believed in the fixity of species and was the uncompromising opponent of the evolutionary views of Geoffroy Saint Hilaire (*Bio. Gen.*; *Gde. Encycl.*).

83. See below, Letter I, n. 1, Appendix, p. 245.
84. See below, Epilogue, pp. 226–227. for a discussion of this curious aspect of Fourier’s philosophy of science.
85. The *salons* of the restoration period are described in Ancelot. Fourier would also have attended the *salon* of Chabrol, and possibly that of the painter Gérard of which his friends Humboldt and Cuvier were members.
86. See Saint Hilaire’s impression of Fourier in Egypt given above, chapter 4, p. 75.
87. Cousin, p. 38.
88. Dirichlet, Peter Gustav Lejeune (1805–59). He completed his studies in Paris where he entered into close relations with the leading mathematicians of the day. Later Fourier recommended him to Alexander von Humboldt who had him named assistant at the University of Breslau. He became successively professor at the General Military School of Berlin (1828), and extraordinary and then ordinary professor at the University of Berlin (1839). In 1855 he succeeded Gauss to the chair of higher mathematics at Göttingen. His researches were mainly in the theory of partial differential equations, the theory of numbers, and the theory of trigonometrical series and integrals. He was elected a Foreign Associate of the Académie des Sciences in 1854 (*Gd. Lar.*).
89. Libri, Guglielmo-Brutus, Count (1803–69). A member of one of the most ancient Florentine families. He was nominated Professor of Mathematical Physics at Pisa in 1823. During a visit to Paris in 1824 he was very well received by all the leading French scientists of the day. He was implicated in a conspiracy and sought refuge in France in 1830 where he became naturalized in 1833 in which year he was elected to the Académie des Sciences in succession to Legendre. He became professor at the Collège de France and was appointed inspector of the libraries of France. But at each visit to a library

the loss of rare books and manuscripts was reported. An investigation was actually begun and then discontinued. On the outbreak of the Revolution of 1848 he was warned of his impending arrest and fled to London where he was received as a martyr. Two years later he was sentenced *in abstentia* in Paris to ten years' imprisonment. Libri arrived in England almost penniless but by the sale of his inexhaustible collection of stolen books and manuscripts he raised more than one million francs. His innocence was protested for many years by a party in France led by Prosper Merimée. In 1888 the French government was able to buy back some of the stolen works. Libri's own most important work was his *Histoire des Sciences Mathématiques en Italie* (*Gde. Encycl.*; *Gd. Lar.*).

90. Duhamel, Jean Marie 1797–1872. He was assistant, then professor (1834) at the École Polytechnique where he had the name of being an excellent lecturer. He was Director of Studies at the École Polytechnique from 1848 to 1851 when he took up the chair of analysis again. He was appointed Professor at the Paris Faculty of Science in 1851. He published a number of memoirs on analysis and rational mechanics. He was elected to the Académie des Sciences in 1840 (*Gd. Lar.*).
91. Pouillet, Claude (1790–1868). He was a pupil at the École Normale where he became a *maître des conférences*. He was appointed physics professor to the children of Louis Philippe (1827), a position which may have helped his later appointments as professor at the École Polytechnique (1831), director of the Conservatoire des arts et métiers (1832), and professor of physics at the Sorbonne (1838). He served for a time as deputy for the Jura and occupied himself with scientific and industrial matters, playing an important part in committees concerned with railways and other technical matters. A disciple of Gay-Lussac and Biot, he is said to have been an excellent lecturer. He made some important experiments on the compressibility of gases. He was elected to the Académie des Sciences in 1837. He retired from all his positions in 1851 following his refusal to take the oath required by the new regime (*Gde. Encycl.*; *Gd. Lar.*).
92. See below Letter VI, n. 10, Appendix, p. 264.
93. See below Letter XI, n. 7, Appendix, p. 290.
94. See below Letter VII, n. 10, Appendix, p. 273.
95. See above, n. 57.
96. Fresnel, A. J. (1788–1827). He had a brilliant career at the École Polytechnique. In 1814 he commenced his researches in light with the encouragement of Arago who became his constant champion in the promotion of his new theories against the criticisms of Laplace, Poisson, and Biot. He was elected to the Académie des Sciences in 1823. Fourier's letter informing him of this election has been preserved.
97. Ampère, A. M. (1775–1836). He was appointed inspector general of the Imperial University in 1808, Professor of Mathematics at the École Polytechnique in 1809 and elected to the first class of the Institut in 1814. Remembered for his fundamental contribution both to the experimental and theoretical sides of electricity and magnetism.
98. Cousin, p. 39.
99. See below, Letter VI, para. 1, Appendix, p. 260.
100. As described by Biot who had himself to extemporize an oration in place of Fourier.

101. *Bib. Nat.*, MS. ff. 22529 fol. 123.
102. See above chapter 5, pp. 101–3, and section 2 of present chapter.
103. Jomard, Edme François (1777–1862). On completing his studies at the Collège Mazarin he entered the École Polytechnique at its foundation and proceeded from there to the École Géographique. He was a member of the Egyptian Expedition. With the help and advice of Fourier he concentrated on topographic work and the exploration of ancient monuments. He became a member of the Institute of Cairo and concentrated on the reconstruction of ancient palaces from their ruined remains. He made important discoveries in numerical hieroglyphics. He was sent to the Palatinate by Napoleon to direct geographical studies including, no doubt, the provision of better maps. By his geological investigation he contributed to the debate between vulcanists and neptunists. He was recalled from Germany in 1803 and made an important contribution to the *Description of Egypt* for which he directed all the works of engraving and printing. He was hard working, modest, simple, obliging and his advice was constantly sought by archaeologists and geographers from all parts of Europe (*Bio. Gen.*; *Gde. Encycl.*).
104. See above, n. 2.
105. See above, chapter 4, n. 22.
106. See above, chapter 4, p. 74.
107. Barrow, **2**, pp. 436–8.
108. See above, n. 21.
109. See above, n. 12.
110. See above, chapter 4, n. 53.
111. Perier, Casimir (1777–1832). He was a witness of the Revolution in Paris and later served for a time in the Army of Italy. Under the Empire he founded a bank with his brother which did much to encourage industrial activity in France and from which he acquired immense wealth. He played a notable part in the Chamber of Deputies under the Restoration. He was forced unwillingly into the party of revolt against the policy of Charles X and his ministers and played a leading part in the July Revolution, entering the government of King Louis Philippe in August 1830 as minister without portfolio. In March 1831 he became President of the Council and it was due to his firm—and on occasion ruthless—use of force that France was prevented from falling again into a bloody revolution and civil war within and war with the combined powers of Europe without. Worn out by incessant labours he was carried off in the cholera epidemic of 1832 (*Bio. Gen.*; *Gde. Encycl.*).
112. See above chapter 3, p. 56.
113. Cousin, p. 38.
114. See below, Letter IV, n. 2, Appendix, p. 256.
115. See below, Letter XII, n. 8, Appendix, p. 295.
116. Cousin, Victor (1792–1867). The son of a poor artisan, he had no regular education up to about the age of eleven, and it was only by chance through protecting a pupil who was being attacked by his schoolmates of the Lycée Charlemaigne that Cousin came to the notice of the mother of this pupil who then had him entered at the Lycée. There he rapidly went to the top and passed out the best pupil of his year. He entered the École Normale becoming assistant in literature at the age of twenty. Later he was drawn to philosophy through the lectures of Laromiguière. From 1815 to 1821 he was assistant in philosophy to Royer-Collard at the Sorbonne where his lectures attracted

great attention by their eloquence and forcefulness. Following the rightwing reaction after the assassination of the Duc de Berri he was dismissed from his position in company with Guizot and Royer-Collard. At this time he paid his second visit to Germany and was imprisoned on suspicion of being a member of the secret society of the Carbonari. On his return to France he was received as a public hero. In 1828 he was appointed by the relatively liberal cabinet under Martignac to the position of Professor of Philosophy at the Sorbonne. Here his lectures were immensely popular and drew large and enthusiastic audiences. At the time of the Revolution of 1830 he was made a Councillor of State and in the same year became a member of the Académie Française in succession to Fourier. He entered the royal council of public education and in 1832 was made a peer of France. He became Director of the École Normale where he expounded to his pupils the philosophy of Aristotle and completed his translation of Plato. In 1840 he was appointed Minister of Public Instruction in the cabinet of Thiers, a position which he occupied for eight months. During this time he flooded Paris with proclamations, pamphlets, decrees etc. and played a prominent part in the debates in the Chamber of Peers where he made many impressive speeches. At the time of the Revolution of 1848 Cousin was against the insurgents and thereafter he disappeared from public life. All that was left to his position in Paris were his rooms in the Sorbonne, and he resigned his lectureship and all his public positions to devote the remainder of his life to writing. Cousin was an eclectic constructing his philosophy from many other philosophical systems following the principle that 'every system is true by what it affirms, and false by what it denies'. The German idealist philosophers, especially Hegel, whose acquaintance Cousin had made in Germany, exercised a particularly strong influence on his thought. But he lacked the patience and perseverance necessary for any real achievement in philosophy. Of much more lasting value than Cousin's philosophy were his contributions to scholarship, especially his criticism of the styles of writers such as Pascal and Rousseau, and his studies of certain little-known historical figures of the seventeenth century. In these fields he was able to exercise all his skill in literary criticism, his delight in discussing points of taste, and his passion as a scholar for fine editions and for the discovery of variants and manuscripts (*Bio. Gen.*; *Gde. Encycl.*).

117. Cousin, pp. 39–41.
118. Ibid., p. 38.
119. Ibid., p. 42.
120. See below, Letter VI, n. 26, Appendix, p. 268.
121. See above, n. 58.
122. *Arch. Nat.* MS. ff. 9118 and na. 4073.
123. Ibid.
124. Ibid.
125. Fourier Dossier AdS.
126. I have not been able to find any information on l'Herminier.
127. *Bib. Mun.* Nantes MS. 281.
128. Lemontey, P. (1762–1826). A deputy at the Leglislative Assembly and later an historian, he was elected to the Académie Française in 1819.
129. *Proc. Verb.*, vol. 8, p. 213.
130. Auger, Louis Simon (1772–1829). From 1799–1812 he was an official in the Ministry of the Interior. His first literary efforts had little success. His mental characteristics were clarity and perseverance rather than vivacity, force, or grace, and he changed to tasks more suited to his powers including laborious and critical works. He worked on the *Décade Philosophique* and the *Journal de l'Emprie* in which he constantly showed himself an admirer of the seventeenth century. He was elected a member of the Académie Française in 1816 at a time when royal ordinance had banished several distinguished members. This irritated liberal writers against him and the irritation was later increased by his nomination to the *commission de censure* which led to repeated attacks against him from which he suffered much. He was very happily married, his wife being a niece of Berthollet and Monge, but he developed a nervous malady which produced profound melancholy. He disappeared from his home on 5 January 1829 and was discovered drowned in the Seine near Meulan on 17 February (*Bio. Gen.; Gde Encycl.*).
131. *Bib. Inst.*, MS. 4501.
132. Larrey, D. J., Baron (1766–1842). In 1792 he joined the Army of the North where he was later appointed principal surgeon. He took part in the Egyptian Expedition and in many other of the military campaigns of the Republic. During the Empire he was surgeon in chief to the *Grande Armée*. His care for the feeding and hygiene of hospital patients earned him the nick-name 'La Providence' among the simple soldiers. He was shunned at first at the Second Restoration but was recalled and became a member of the Académie de médecine (1820) and was elected to the Institut (1829). He wrote a number of important works in military surgery (*Gde. Encycl.*; *Gd. Lar.*).
133. Blanchin, J.-B. (?——1836). Educational writer. Author of a number of popular school books.
134. Dupuytren, G. (1777–1835). French surgeon famed for his innovations, his mastery of operating techniques, and his ruthless pursuit of power. He was a member of the Institut and a professor at the Paris Faculty of Medicine to which he left on his death the sum of 200 000 francs for the foundation of the museum bearing his name.

PART II

FOURIER THE PHYSICIST

7

CHRONOLOGICAL ACCOUNT OF RESEARCHES IN HEAT

THE beginning of Fourier's theoretical researches in heat cannot be dated with any certainty. It could have been as early as 1802 soon after his move to Grenoble, and it was certainly not later than around 1804.[1] What is certain is that his first theoretical approach to the subject was through consideration of the movement of heat between a finite number of discrete bodies arranged in a straight line.[2] His solution to this problem is preserved in a manuscript form in his Draft Paper,[3] a work which was possibly intended for publication and which was in any case completed around 1804–5. The same problem, later much extended, appears in the 1807 memoir,[4] the Prize Essay[5] and the Analytical Theory.[6] Physically it was a blind alley though it led to important mathematical advances in the treatment of trigonometrical expansions, and it appears in the Prize Essay and the Analytical Theory largely as an historical monument to Fourier's earliest work in the theory of heat in much the same way as the second proof of the law of centrifugal force in the *Principia*[7] is a memorial to Newton's earliest work in dynamics.

Apart from the transmission of heat between a finite set of discrete bodies, and an unsuccessful though suggestive attempt to extend the solution to the case of an infinite set of bodies, the Draft Paper of 1804 contains a first incomplete, and largely erroneous, treatment of the distribution of temperature in a thin bar heated at one end.[8] A flattering reference[9] to a paper of 1804 by J. B. Biot[10] on the same topic makes it reasonably certain that it was this paper—of which the contents may have been communicated to Fourier before the publication of the paper itself—which first stimulated Fourier to turn his attention from the physically unimportant if mathematically interesting problem of the transmission of heat between discrete bodies to the real problem at issue—the propagation of heat in continuous bodies. The other problem treated in the draft paper of 1804, this time in a definitive way requiring no significant alterations in all subsequent versions, was that of the semi-infinite strip with its edges and end held at constant temperatures.[11] The treatment is memorable for Fourier's first use of trigonometrical expansions in the theory of heat, for his brilliant treatment of the question of convergence of such expansions, and for the heroic manner in which the coefficients of the various cosine terms in the expansion are determined by purely algebraic means. Prior to the treatment of semi-infinite strip partial differential equations are given for the general, non-steady, motion of heat in one, two, and three dimensions.[12] These are incorrect as regards omission of the specific heat in the term involving the time rate of change of the temperature, and the appearance *in the equations* of a term corresponding to heat loss at the surface of the solid—though Fourier does express uncertainty as to whether or not the latter term should be included. By chance or design both errors are avoided in the case of the semi-infinite strip since the temperature distribution is assumed to be steady while the fixing of the temperatures at the edges and end obviates the need for any separate consideration of heat loss.

It seems probable that the draft paper was completed around the period 1804–5. His next work, the 1807 memoir, was said[13] to have been completed towards the end of 1807, and was in any case read before the Institute on 21 December of that year. This memoir represents an enormous advance on the draft paper as regards physical and mathematical understanding of the underlying problems, and the number and variety of applications. No manuscript evidence has survived of the manner and pace of the development between the two works, though the draft paper itself contains definite indications in its introduction—evidently written in the manner of introductions after the body of the paper—which point towards a very rapid development on both the physical and mathematical sides beyond the level of the ensuing text. For example, a reference to the treatment of discrete bodies states that they are arranged in a *circle*, whereas in the body of the paper the discrete bodies are arranged in a straight line, and it is only from the 1807 paper onwards that consideration is given to bodies arranged circularly. Likewise, in the introduction it is stated that on making the number of separate masses tend to infinity while the size of each tends to zero the result obtained is 'in agreement with that given by the principle of Newton', whereas once again in the body of the paper itself this limiting process is imagined to apply to bodies arranged in a straight line and is certainly not carried through to a conclusion. Another indication of a major advance in Fourier's treatment of the mathematical problems involved is his comment in the introduction that he had originally obtained trigonometrical expansions by means of very laborious eliminations, but that now he employed a much more general and much more expeditious rule to resolve an arbitrary function into series of sines and cosines. Once again this method was not used in the body of the paper itself.

Reference to the need for experimental investigations as an aid to the elucidation of certain outstanding obscurities relating to the problem of a heated bar is also to be found in the body of the paper.[14] Elsewhere[15] Fourier refers to a series of very careful experiments carried out over a period of two years before the writing of the 1807 memoir in which he repeated all important experiments which had been carried out previously in England, France, and Germany and added experiments of his own concerned with the propagation of heat in solids and liquids. If these experiments were originally directed towards the elucidation of particular problems associated with a heated bar, they ultimately had the much more important function of making Fourier thoroughly conversant with the various physical aspects of the phenomena of the propagation of heat including the role of specific heat in the full, time-dependent equation of motion of heat. By 1807, the pure mathematician of the draft paper, interested in the problem of the flow of heat with as superficial an understanding of the physical side of the problems involved as Biot in 1804 or Laplace in 1809, had become the complete theoretical physicist in the manner of Newton and Fresnel, his genius for mathematical manoeuvre now firmly based on an intimate understanding of the relevant physical concepts including specific heat,[16] conductivity,[17] and heat flow.[18] Fourier's experimental investigations in the two years or so preceding the completion of the 1807 memoir had one further outcome: by careful choice of the most suitable experiments they enabled him to give a number of striking experimental confirmations of his new theory. These—as he modestly noted in the introduction to the 1807 memoir—'contributed to give to the theory an authority which one might have been inclined to refuse in a matter still obscure and apparently subject to so many uncertainties'.[19]

The 1804 draft paper is a curiously uneven work: the treatments of a finite set of discrete bodies and of the semi-infinite strip are so definitive and complete as to require no essential changes in all later versions, and both are stamped with the elegance, clarity, and daring characteristic of Fourier's genius in pure mathematics. But this mathematical mastery exists in uneasy partnership with an equally great uncertainty on the physical side epitomized by the failure to realize the need for a knowledge of an exact quantitative expression for the heat flux across any given section, the totally erroneous derivation of the equation governing the steady distribution of temperature in a 'thin' bar, the absence of the specific heat in the general non-steady equation of propagation of heat, and the uncertainty as regards the appearance in this same equation of a surface heat-loss term. In the 1807 memoir the situation is transformed: this is no longer a paper but a *treatise*. It is incomplete compared with the Prize Essay only as regards a certain residual inadequacy in the treatment of the heat flux and the derivation of the equations of motion, in the omission of a treatment of the cooling of infinite solids, and in discussions of terrestrial and radiant heat, so that it is difficult not to agree with Fourier's view[20] that the setting of a Prize Essay was unnecessary since the problems it propounded had already been solved in the 1807 memoir.

Apart from the fact that the treatment of discrete bodies in a straight line immediately after the introduction as in theDraft Paper, the structure of the 1807 memoir is already very close to the Prize Essay and the Analytical Theory of Heat. Following a discussion of fundamental physical concepts including conductivity and the expression for flux of heat,[21] the equation for the propagation of heat in a thin rod is formulated and solved for the steady state,[22] followed by a similar treatment for a thin ring.[23] Then follows the derivation of the full interior equations of propagation of heat in a sphere[24] and a cylinder[25]: in both cases the derivation of the equation is *ad hoc* making use of special symmetries, but consideration of a finite cube[26] leads to the derivation of the general equation of propagation of heat within any solid,[27] the previous equations for the cylinder and the sphere being re-derived as special cases of this general equation.[28] Up to this point no solutions have been obtained except in the trivially simple cases of the thin rod and the thin ring. Apart from the final section on experimental investigations,[29] the remainder of the memoir is taken up with the derivation of solutions starting with the case of the semi-infinite strip,[30] followed, as in the case of the Prize Essay and the Treatise, by a prolonged discussion of trigonometrical expansions of various functions.[31] The general (time-dependent) solution of the thin ring is considered next,[32] and subject to certain plausible identifications between parameters, this is shown[33] to be the same as the limiting solution for a set of discrete bodies arranged circularly as the number of bodies tends to infinity and the mass of each tends to zero in such a way as to lead to a continuous circular distribution. Discussions of the cooling of a sphere,[34] a cylinder,[35] and a cube,[36] and the steady-state distribution for an infinite prism[37] complete the contents of the memoir apart from the final section on experimental investigations.

The sheer size and range and diversity of application is so much greater in the 1807 memoir than in the Draft Paper that it is at first sight difficult to distinguish the really fundamental advances in the former over the latter work. But a careful comparison reveals that these advances were almost all on the physical side. In the Draft Paper Fourier clearly displays the sort of mathematical mastery which will be equal to any of the problems likely to be thermal phenomena.[38] What is lacking is a thorough understanding of the underlying physical processes. Having acquired this understanding and having hit on the correct expression for the heat flux at any point of a heated body, the way was then open for him to formulate correctly the equations of the propagation of heat in the interior of any solid body. It then only remained to formulate separately the appropriate boundary conditions at the surface of the solid in question—the direct involvement of a heat-loss factor in the equations of propagation in a thin rod being evidently an idealization resulting from the assumption of a constant temperature over sections perpendicular to the length—for the whole subject of the propagation of heat to be reduced to a matter of mathematical analysis which Fourier then proceeded to apply to one case after another.

Fourier read an abstract[39] of his memoir before the First Class of the Institut on 21 December 1807. The commission set up to report on the memoir consisted of Lagrange, Laplace, Monge, and Lacroix. The composition of the commission, the experimental confirmation of his theory, and the fact that he had reached many of the principal mathematical results by independent methods[40] must have made Fourier confident of the outcome of the commission's work. In fact, the first reaction to his memoir came in a review by S. D. Poisson[41] in the *Bulletin of the Philomatic Society*. It stated the prime objective of the work, the determination of the temperature at all points of a heated body both in the steady state and in the case of cooling, referred to the equations for the propagation of heat both in the interior and at the surface of solids, listed the special cases treated by Fourier, and noted the experimental confirmation of the theory, especially the remarkable case involving the temperatures at diametrically opposite points in the cooling of a heated ring. The review, if not enthusiastic, was perfectly fair and correct in manner,[42] and there were only two points at which any sort of criticism implied or otherwise could be read into Poisson's comments, and then only with hindsight in the light of his subsequent criticism of Fourier's work: the first was the fact that he reproduced Biot's erroneous treatment of a thin bar, something which might have been taken to imply that Fourier's ostensibly similar but actually quite different treatment was incorrect; and the second was his comment that the investigation of the new equations of propagation of heat posed 'delicate questions in the theory of heat deserving the attention of mathematical physicists'[43] which could have been taken to imply that Fourier's own investigations of these questions were not altogether satisfactory.

Poisson's review was the only public reference to Fourier's memoir outside the proceedings of the First Class of the Institut and certain references by Fourier himself at a much later date, and in spite of a request by the First Class to the commission to hurry up its work[44] no report ever appeared. Instead a lively controversy arose involving two major criticisms of Fourier's work which between them struck at its very foundations on both the mathematical and physical side. The first was directed at his use of trigonometrical expansions, the second at the validity of the method he had employed to derive the fundamental equations for the propagation of heat in the interior of continuous bodies. The chief critics of his use of trigonometrical expansions seem to have been Laplace and Lagrange. It appears that Laplace had maintained that the expansions given by Fourier of cosine x in terms of sines, and of sine x in terms of cosines were 'contrary to the principles of the calculus'.[45] Fourier corrected this misapprehension in a letter to Laplace of which a partly legible draft has survived.[46] On the contrary he maintained against Laplace that the results could be 'demonstrated rigorously' spelling out exactly what was meant by the claim that a given function was equal to the sum of an infinite number of trigonometrical terms, referring to his brilliant method of expressing the sum of the first m terms of the infinite series as a function of $1/m$, which tended in the limit of large m to the sum in question. In a letter,[47] probably to Lagrange, he made the same point at greater length—and in a more tactful manner—referring especially to the series

$$\tfrac{1}{2}x = \sin x - \tfrac{1}{2}\sin 2x + \tfrac{1}{3}\sin 3x \ldots$$

whose convergence was 'clearly' established by a note accompanying his letter. It seemed to Fourier that if such demonstrations were to be forbidden it would be necessary to give up writing 'anything exact in mathematics'. While apologizing for the absence of any reference to earlier work on the same subject by Euler and d'Alembert due to his inability to consult any mathematical works during the researches leading to the 1807 memoir, he also made it clear that he regarded Euler and d'Alembert's use of trigonometrical series as inadequate compared with his own on the grounds, firstly, that they were 'both persuaded that an arbitrary and discontinuous function could never be resolved in series of this kind', and secondly that no mention was made of limits within which a given trigonometrical expansion held. In any case Fourier's use of trigonometrical functions was only a 'particular case' among others which he had to treat, which later 'offered analytical difficulties of a very different order' and he referred specifically to the section on motion of heat in a cylindrical body[48] which he regarded as the only part of his work worthy of Lagrange's attention.

The second major criticism of Fourier's work was directed against his derivation of the equations of motion of heat in a continuous solid. The polemical aspects of this side of the controversy have already been noted,[49] especially Fourier's angry reaction to an implied criticism of his work contained in a certain passage in an article by Biot appearing in the *Mercure de France*.[50] The 'analytical difficulty' somewhat obscurely referred to by Biot in this passage had already been expressed explicitly in an appendix to a paper by Laplace[51] in which the problem of the flow of heat in a narrow bar was treated by 'molecular' considerations similar to those he had employed in the body of the paper in the case of the refraction of light. Such a treatment was necessitated by the fact that one based on consideration of three consecutive 'points' of the bar led to a differential equation in which the two sides were of different orders of magnitude. This was certainly true of the quantitative treatment of the same problem in Fourier's draft paper of 1804–5 which had itself arisen out of the qualitative treatment in Biot's paper of 1804. There is some reason to believe that Fourier sent Biot and Poisson a copy of this draft paper, or possibly an early draft of the 1807 memoir which may still have contained the erroneous treatment and it may have been this treatment which Laplace had in mind.[52] But he was quite unjustified in applying the same criticism to Fourier's 1807 memoir, and his own treatment, though typically ingenious, compared unfavourably in certain physical respects with that given by Fourier.[53] Nevertheless, although the criticism of Biot and Laplace was unjustified, and was made in a somewhat underhand manner calculated to cause the maximum annoyance to Fourier, it had the virtue of stimulating him to a justification of his method of deriving the equation of motion for heat which led to a significant improvement over the treatment given in the 1807 memoir. This improvement was later incorporated in the Prize Essay and the Analytical Theory of Heat. Traces of it were given in certain marginal notes to the 1807 memoir,[54] and it was then fully worked out in a long letter to an unknown correspondent dating from around 1809–10.[55] It corresponded to the transition from the 'three slice' approach found throughout the 1807 memoir—itself reminiscent of the 'three point' approach of Biot's qualitative treatment of 1804, and Fourier's erroneous, quantitative treatment in the draft paper—to the 'single slice' approach found in the Prize Essay and the Analytical Theory of Heat.[56] This transition also met the criticism of Biot[57] and Laplace[58] that the 'analytical difficulty' could not be surmounted unless account was taken of 'points' other than those immediately adjacent to the 'point' at which the heat flow in the bar was to be calculated.

Apart from these two major criticisms of Fourier's work there were at least two of lesser importance directed, respectively, against his form of the surface equations,[59] and against the reality of the roots of the transcendental equation involved in the problem of the cooling of a heated sphere.[60] Fourier's form of the surface equations—as compared with a surprisingly naïve suggestion put forward by Laplace[61]—was ultimately accepted but once again Poisson maintained the superiority of his own derivation of the same equations. The other question proved more recalcitrant and led to papers by both Fourier and Poisson after the appearance of the Analytical Theory itself.[62]

The controversy over Fourier's work in heat took a new turn at the beginning of 1810 when the propagation of heat in solid bodies was announced as a subject for the Institut's grand prize in mathematics for the year 1811. The committee set up to examine submissions for the prize consisted of Lagrange, Laplace, Malus, Haüy, and Legendre.[63] There was one other candidate apart from Fourier. Fourier's submission consisted of the memoir of 1807 together with certain new sections, especially those on the cooling of infinite solids, and on terrestrial and radiant heat.[64] The treatment of the cooling of infinite solids was an obvious omission from the 1807 memoir, probably due to Fourier's inability at that stage to handle the mathematical problems involved, since treatments are given of several cases of the *steady* distribution of temperature in infinite solids. It is possible that Fourier was stimulated in a search for solutions of the full diffusion equation for the infinite line by a paper of Laplace in which a solution to the equation was given in terms of an integral.[65] But he could have developed his own method[66] involving Fourier integrals independently, and the only major use made of Laplace's solution in the Prize Essay is as a check of Fourier's own methods. As regards the section on terrestrial heat,[67] according to Fourier this topic provided one of the major incentives for the development of his analytical theory of heat in the first place,[68] and the section on radiant heat[69] could well have been stimulated by Fourier's reading of a work by the Swiss physicist Prévost.[70] In spite of these important additions the Prize Essay was still identical with the 1807 memoir as regards its essential contents on both the physical and mathematical sides. The unresolved differences of opinion over the earlier memoir might then have been expected to extend to Fourier's submission for the Prize Essay. Nevertheless the prize was awarded to Fourier. The Institut might thus have been thought to have set the final seal of its approval on Fourier's work. In fact, the report[71] on Fourier's essay contained serious reservations which made it plain that the commission, in other words Laplace and Lagrange, who were not only its most powerful and influential members, but also much more familiar with Fourier's work than any of their colleagues, were still unreconciled either to Fourier's method of deriving the fundamental equations for the propagation of heat or to his use of trigonometrical series in their solution.

The serious reservations contained in the referees' report elicited a letter[72] of protest from Fourier to the permanent secretary Delambre, apparently without effect.[73] At the same time the Institut seemed in no hurry to publish the essay. As long as he remained 'exiled' from Paris and unable to become a full member of the Institut there was little Fourier could do about this. In any case he must have been much too preoccupied with prefection duties during the decline of the Napoleonic regime, the First Restoration, and the Hundred Days to do any work on the theory of heat. But on his return to Paris in June 1815 he would have been alarmed to read an article by Poisson in the *Journal de Physique*.[74] In this article Poisson referred to Fourier's Prize Essay of 1811 which he had been allowed to consult at the secretariat of the Institut. While conceding that Fourier's essay contained the correct equations of propagation of heat as regards both the interior and the surface of conducting bodies, and that the experimental confirmation of the results obtained in the case of a sphere and certain other solids provided a simultaneous justification of the results themselves and the theory on which they were based, it seemed to Poisson that the analysis employed by Fourier was not 'devoid of difficulties' and did not appear to have 'all the rigour and generality required by the importance of the question'.[75] The similarity between this criticism and that contained in the report on the Prize Essay is striking and may not have been entirely fortuitous. It appeared that Poisson's criticism was partly directed against the use by Fourier of solutions to differential equations in terms of trigonometrical expansions, and he recalled Euler, d'Alembert, and Lagrange's criticism of Daniel Bernouilli's similar use of trigonometrical solutions in the problem of the vibrating string.[76] Poisson himself favoured a solution to the differential equation of propagation of heat in terms of a single arbitrary function as originally shown by himself in 1806[77] and confirmed later by Laplace[78] in 1809. By extending Laplace's form of solution from one to three dimensions Poisson claimed that he was able to treat in his own, and supposedly more general, manner all the cases for which solutions had been provided by Fourier in terms of trigonometrical series. This he regarded as 'the true solution to the problem'[79] in implied contrast to the method employed by Fourier. To this claim Fourier gave an unanswerable response in his unpublished Historical Précis[80] in which he pointed out that *any* solution of the full heat propagation equation taking given arbitrary values at all points at an initial time must be the *only* solution. So that any two correct solutions which appear to be different must in fact be identical. To drive the point home he went on to prove[81] that the solution in terms of trigonometrical functions for a ring of radius *R* gave the same solution as *R* tended to infinity as that given by Poisson for an infinite bar. The same argument was later reproduced in the Analytical Theory of Heat. In another paper[82] Poisson gave an example of his approach to the solution of the heat propagation equation by providing a solution for the case of a bar initially heated in some arbitrary manner over a given finite length and then allowed to cool. Unfortunately for Poisson his analysis was invalidated by an elementary error which

Fourier had no difficulty in pointing out in a letter to Laplace.[83] This probably represented the final turning point in Fourier's struggle for recognition.

In his first paper Poisson had also criticized Fourier's work on the familiar grounds that although the equations of propagation were correct the derivation given them in the simplest case of a thin bar led to an incompatibility of differentials on the two sides of the equation. Echoing Biot's opinion, he said that this difficulty could not be overcome except by employing Laplace's method for deriving the expression for the rate of flow of heat in terms of the temperature gradient from certain plausible suppositions regarding the passage of heat between individual 'molecules'. Using this method Poisson had obtained the same results as those given by Fourier whose demonstration, however, 'left something to be desired'.[84] The next year (1816) Biot[85] advanced exactly the same argument as Poisson for overcoming the supposed difficulty. In a footnote[86] he even claimed that he (Biot) had been the first both to 'enunciate and apply' the correct equation for the propagation of heat in a stationary case. In the same footnote he also criticized Fourier's use of trigonometrical expansions while praising the methods adopted by Poisson. These charges, which had of course been advanced before by Biot in his *Mercure de France* review of 1809, were dealt with by Fourier in a separate note of his Historical Précis[87] in which he had little difficulty in showing up the falseness of Biot's claim to have been the first 'to enumerate and apply the correct equation'. Indeed, as Fourier remarked, he could not have done so without a knowledge of the correct expression for the flux of heat. Being ignorant of this he was in no position to find the equation. He then proceeded to go over the usual argument in favour of the expression he had adopted for the flux of heat, and to expatiate at considerable length on the nature of the double error which led Biot to the correct equation.

Nothing more is heard of the criticisms of Biot and Poisson after Fourier's withering reply in his letter to Laplace and his unpublished Historical Précis. Thereafter their 'conspiracy' seems to have collapsed. Nevertheless Fourier could not have felt entirely confident as long as his Prize Essay remained unpublished. This may account for a number of papers[88] published in various journals between 1816 and 1822 which are largely in the nature of extracts from the Prize Essay. It is commonly said that Fourier was himself responsible for having his Prize Essay published as soon as he became permanent secretary of the Académie des Sciences. Although it is true that the Essay was published in succeeding numbers[89] of the memoirs of the Académie des Sciences after he had become permanent secretary, nevertheless the actual publication was put in hand at an earlier date as is evident from a letter of Delambre to Fourier,[90] and also by a reference by Fourier himself in notes following the reproduction of his Essay.[91]

A little before he became permanent secretary of the Académie des Sciences for the mathematical sciences Fourier had the pleasure of presenting his Analytical Theory of Heat to the Institut.[92] This omits the chapters on terrestrial and radiant heat, and on experimental results found in the Prize Essay, but otherwise differs in no really important respect from that work. Like the Prize Essay this work had also been very slow in printing.[93] With the publication of his Analytical Theory and of the Prize Essay Fourier's fears about possible priority claims or plagiarism of his work must have come to an end. In the remaining years of his life he published a number of further papers on the theory of heat including applications to terrestrial heat, to the theory of radiation, and to the motion of heat in fluids.[94]

Notes

1. Because of a reference to a paper of 1804 by J. B. Biot (Biot (1)) in the Draft Paper.
2. In the notes at the end of the published version of the Prize Essay Fourier states that 'the first analytical researches of the author on the communication of heat were concerned with its distribution between disjoint masses: they have been preserved in the first part of the memoir'. *Œuvres* **2**, p. 94.
3. Draft Paper fol. 109 bis–122.
4. 1807 memoir, arts. 1–13.
5. Prize Essay, arts. 38–43.
6. Analytical Theory, chapter IV, sect. 2.
7. Newton *Principia*, Book I. Prop. IV, Theor. IV, *Scholium*.
8. See below, chapter 8, pp. 164–5.
9. Draft Paper, fol. 124–4 v.
10. Biot (1).
11. Draft Paper, fol. 128ff.
12. Draft Paper, fol. 125–5v.
13. According to Historical Notes.
14. Draft Paper, fol. 127v.
15. Historical Précis fol. 162.
16. 1807 memoir, art. 15.
17. Ibid., arts. 16, 17.
18. Ibid., arts. 17, 18.
19. Ibid., fol. 3.
20. Historical Notes.
21. 1807 memoir, arts. 15–18.
22. Ibid., art. 19.
23. Ibid., art. 24.
24. Ibid., art. 25.
25. Ibid., art. 26.
26. Ibid., art. 28.

27. Ibid., art. 29.
28. Ibid., arts. 30, 31.
29. Ibid., arts. 159–67.
30. Ibid., art. 32.
31. Ibid., commencing at art. 34.
32. Ibid., arts. 76–94.
33. Ibid., arts. 95, 96.
34. Ibid., arts. 97–114.
35. Ibid., arts. 116–39.
36. Ibid., arts. 152–8.
37. Ibid., arts. 140–51.
38. With the possible exception of the treatment of diffusion in infinite solids which had to await the Prize Essay and represented a definite advance mathematically over anything found in the 1807 memoir.
39. This abstract has been preserved in MS. 1851, École des Ponts et Chaussées, Paris.
40. As he states in Letter XXI to Lagrange, Appendix, p. 318.
41. S. D. Poisson (2).
42. I can find no reasons for Grattan-Guinness's opinion that this review represented 'the ultimate in denigration' of Fourier's work. See Grattan-Guinness (1), p. 250.
43. Poisson (2). See *Œuvres*, **2**, p. 215.
44. See *Proc. Verb.*, vol. 4, p. 299: *séance* of 15 Jan. 1810.
45. See below, Letter XX to Laplace, Appendix, p. 316.
46. Ibid.
47. See below, Letter XXI, Appendix, p. 318.
48. In this section Fourier for the first time treated the cylindrical or Bessel functions.
49. See above, chapter 5, pp. 101–2.
50. Biot (2).
51. Laplace (3), pp. 290–5.
52. In Letter XXI to Lagrange(?) Fourier states that he transmitted part of his work 'two years ago to M. Biot and M. Poisson'. It is evident from the context that he is referring to a time before the submission of the 1807 memoir.
53. For example, there was no indication in Laplace's treatment of how the constant involved in the expression for the heat conduction depended on the dimensions of the bar or the material of which it was made up.
54. 1807 memoir, art. 18.
55. See below, Letter XIX, Appendix, p. 307.
56. This topic is discussed below in chapter 8, pp. 166–7, and chapter 9, p. 185.
57. Biot (2), p. 336.
58. Laplace (3), p. 291.
59. This is referred to in item 6 of notes to abstract of memoir contained in MS. 1851, École des Ponts et Chaussées, Paris, also in *Historical Notes*.
60. Ibid., item 5.
61. Laplace (3), p. 294. See discussion of this below, chapter 8, p. 170.
62. See especially Fourier's 1829 paper 'Remarques Générales sur l'Application des Principes de l'Analyse Algébraique aux Équations Transcendantes'. *Œuvres*, **2**, pp. 185–210.

63. *Proc. Verb.*, **4**, p. 544: *séance* of 7 Oct. 1811.
64. See *Œuvres*, **2**, p. 94, for Fourier's description of the contents of the Prize Essay.
65. Laplace (2). Fourier refers to this paper in his Historical Précis, fol. 155.
66. Given in Prize Essay arts. 66–79.
67. Prize Essay, arts. 80–8. See below chapter 10, pp. 197–202.
68. See above, chapter 5, n. 22.
69. Prize Essay, arts. 89–100. See below chapter 10, pp. 202–5.
70. Prévost (1).
71. Reproduced in *Œuvres*, **1**, p. vii.
72. The letter itself seems to have disappeared.
73. See letter from Delambre to Fourier in BN MS. ff. 22529, fol. 119.
74. Poisson (3).
75. Ibid., p. 434.
76. See Fourier's own reference to this controversy in 1807 memoir, fol. 114–15. For critical accounts see Bose (2); Langer; Mach, pp. 93–7; Grattan-Guinness (3), chapter 10; Ravetz (2). The last named work contains a useful bibliographical note at p. 71.
77. Poisson (1).
78. Laplace (2).
79. Poisson (3), p. 435.
80. Op. cit., fol. 161–2.
81. Ibid., fol. 161–161v. The question of uniqueness is discussed below in chapter 8, pp. 175–7.
82. Poisson (4).
83. BN MS. ff. 22525, fol. 82–2v, 83–4v, 98.
84. Poisson (3), p. 439.
85. Biot (3).
86. Ibid., p. 669, n. 1.
87. Historical Précis, fol. 157–8v.
88. Especially the first of these: 'Théorie de la Chaleur', *Ann. Chimie Physique*, **3** (1816), 350–75.
89. *Mémoires de l'Académie Royale des Sciences*, **4** (1819–20: publ. 1824), 185–555; ibid., **5** (1821–2: publ. 1826), 153–246.
90. BN MS. ff. 22529, fol. 121.
91. *Œuvres*, **2**, p. 94.
92. *Proc. verb.*, vol. 7, p. 274.
93. In his letter of 11 April 1816 to the President of First Class (see below Letter XXVIII) Fourier claimed that 360 pages of his work had already been printed.
94. See below, chapter 10.

8

DERIVATION AND SOLUTION OF THE EQUATION OF MOTION OF HEAT IN SOLID BODIES

IN discussing Fourier's derivation and application of the equations governing the propagation of heat within continuous solids we shall follow Fourier's own method from the 1807 memoir onwards of making a sharp division between the *derivation* of the equations of propagation in various cases and the *solution* of the same equations subject to certain initial and boundary conditions. Section 8.1 of this chapter will therefore be devoted to the derivation of the equations of propagation of heat and section 8.2 to their solution. Fourier gives no reason for this separation between derivations and solutions. Probably it was simply an index of his orderly mind and a tendency to separate the largely *physical* thought processes of the derivations, above all in the critical case of the thin rod, from the purely *mathematical* processes involved in their solution. It has proved an appropriate division for the purpose of the present book which is principally concerned with Fourier the physicist rather than Fourier the mathematician. Much consideration has already been given[1] to the mathematical aspects of Fourier's work in the theory of heat and the account given in section 8.2 is intentionally concise. In contrast, very little attention has been given to the physical aspects of Fourier's work and the treatment in section 8.1, especially in the case of the thin bar, is much more detailed and contains new insights into Fourier the theoretical physicist.

1. Derivation of equations

It seems reasonably certain that Fourier was first stimulated to turn his attention from consideration of discrete bodies to that of a continuous body by Biot's paper of 1804.[2] This paper was principally concerned with the steady state temperature distribution in a thin bar heated at one end and in contact at its surface with air or other medium contained at constant temperature assumed zero. On the basis of careful observations it appeared that the decrease in temperature with distance from the heated end always followed a logarithmic law. This explained why a thermometer placed at a distance of six feet from the heated end showed no observable temperature rise above that of the surrounding air. For Biot calculated that a difference of one degree would have required a temperature of some 23 984 Réaumur at the heated end, that is a temperature of the order of four times the temperature of melting iron as measured in the experiments of Wedgwood. On the basis of this result for the particular iron bar employed Biot concluded:

> Thus it is physically impossible to heat to one degree the end of an iron bar of two metres or six feet in length by heating the other end, because it would melt before this.[3]

This rash generalization to all iron bars of the result true for a particular one was later to lay Biot open to a devastating attack by Fourier.

Biot's paper was largely concerned with observational results and he gives references by various earlier works on the same topic by Newton and Ingenhouss.[4] Curiously, however, it contained no references to two papers by Amontons[5] and Lambert.[6] Amontons work was apparently the first in which the variation in temperature of a bar heated at one end was employed as a 'thermometer' for measuring the melting points of various solids. To this end he assumed that the temperature decreased *linearly* with the distance from the heated end. An important advance over this position was then made by Lambert. From a passage in Lambert's work it is clear that he achieved a pretty complete qualitative understanding of the process of conduction of heat in the bar. For example at one point he says:

> However, the heat flows gradually to the more distant parts, but at the same time travels from each part into the air. So that when the fire has burnt and been maintained long enough at the same strength, every part of the bar finally acquires a definite degree of heat because it constantly acquires as much heat from parts of the rod nearer the fire as it transmits to the more distant parts *and* the air. This stationary state will now be considered separately.[7]

Lambert then gave a fairly plausible though incomplete justification for a *logarithmic* decrease of temperature with distance which he proceeded to test experimentally.

It was only some considerable time after reading Biot's paper that Fourier learnt of the existence of the papers of Amontons and Lambert. He was later[8] inclined to blame Biot for failing to give any reference to their work in his 1804 paper, the implication being that Biot had been indebted to them, especially to Lambert, for the ideas in his own paper. There is no way of deciding if Fourier's poor estimate of Biot was justified. What is certain is that the short section in Biot's paper in which he attempted to give a theoretical investigation of propagation of heat in a thin bar bore a striking resemblance in part to the discussion of Lambert. Each point of the bar, he argued,[9] received heat from the point which preceded it, and communicated some of it to the point which followed. The difference of heat was what remained to the point as a result of its distance from the source and its loss to the air by immediate contact and by radiation. In the equilibrium state, when the temperature of the bar was stationary, the increase of heat in each point of the bar by reason of its position would equal that which it lost to the air, and by Newton's law this loss was proportional to its temperature. In a non-steady state the increase of temperature in a given interval would equal the quantity of heat gained by reason of position minus the quantity lost by radiation. The condition for temperature equilibrium being reduced to calculation gave an ordinary differential equation of the second order between the increase of the temperature and the distance from the source of heat. This equation had constant coefficients and could be integrated. In the non-stationary state an extra variable, the time, was introduced to give a partial differential equation of the second order. This second equation contained the first as a special case. Only the steady state problem was considered in which the integral contained two arbitrary constants, and a non-arbitrary constant which depended on the ratio of the 'conductivity' to the 'radiation'.[10] These three constants depended on the special conditions of the bar and could then be determined by observation. At a great distance from the source there would be no effect, and the temperature would be equal to that of the surrounding air or other medium. This condition eliminated one of the exponential terms. In practice there were no infinite bars but for bars which were sufficiently long the temperature difference at the end would be approximately zero.

Contrary to what Biot was to claim later,[11] the theoretical arguments in his 1804 paper were of a purely qualitative nature. The first known attempt at a *quantitative* treatment of the same problem, albeit of a very tentative and incomplete nature, is contained in section 3 of Fourier's Draft Paper.[12] There he considers three consecutive slices of the bar at temperatures y_1, y_2, y_3, and argues that, other things being equal, the heat *entering* the middle slice from the left slice will be proportional to $y_1 - y_2$ or δy_1, and the heat *leaving* the middle slice for the right-hand slice will be proportional to $y_2 - y_3$ or δy_2. So that the net heat which remains in the middle slice will be proportional to $\delta y_1 - \delta y_2$ or $\delta^2 y_2$. But since the state of the bar is assumed to be steady there must be an exact balance between the net gain of heat in the middle slice and the net loss of heat to the air at the corresponding portion of surface. The air is evidently assumed to be at temperature zero and the loss in question will therefore be proportional to the temperature y_2 of the middle slice, assuming that the cooling follows Newton's Law. Expressing the heat balance for the assumed steady state would then lead to $\delta^2 y_2 \sim y_2$. But this poses a serious and apparently insurmountable difficulty, for the left-hand term is of the second order of small quantities, while the right-hand term is of zero order of small quantities. Something else must therefore be taken into account. In the first place, argues Fourier, a cylindrical slice has with a succeeding slice a contact 'incomparably more extended' than that which it has with the surrounding medium (air). This leads to an additional term δx on the right-hand side of the equation. But the equation is still unbalanced as regards order of magnitude, and to right this Fourier has to make the curious assumption that since consecutive slices across which the heat flow takes place are 'infinitely thin' the heat will be conveyed across them 'infinitely more easily' than in the case of the heat lost to the air at the curved surface of the bar. This yields a further additional term δx on the left-hand side leading to an equation of the correct form

$$\frac{\delta^2 y}{\delta x^2} = \text{const.}\, y.$$

The unsatisfactory nature of this derivation needs no stressing, and no doubt Fourier himself did not feel very happy about it. A possible indication of this is provided by the fact that he makes no attempt to solve the equation in spite of its simplicity. This could have been accounted for by Fourier's uncertainty at this time of the actual nature of the sign of the right-hand side whether positive or negative. In this connection a reference to Biot's paper in the introduction to the draft paper is of interest:

> Moreover the calculation does not suffice to remove all the uncertainties of this theory of the movement of heat. There are those which will only be resolved by means of experiment. This is what M. Biot has already undertaken with the greatest success. He has been good enough to communicate to me the first results obtained in his printed memoir.[13]

Or again referring to the heat loss at surface of the bar:

> I particularly desire to know how the figure, polish, or dullness of the surface modifies the effect of this property.[14]

Although Fourier's derivation of the equation for the propagation of heat in a thin rod in the draft paper was erroneous, it did contain the germs of a more satisfactory treatment as regards consideration of consecutive slices and the notion of heat balance in the steady case. What was missing was a knowledge of the rate of flow of heat across a given element of area. This was first supplied in the 1807 memoir[15] where he gives a careful justification of the assumption that the heat flow per unit of area is proportional to the gradient of temperature, the constant of proportionality K (the internal conductivity) depending on the substance in question. Armed with this result he then considers a bar having a square cross-section of side l sufficiently small for the temperature to be assumed constant over any section perpendicular to the length of the bar. The prism is divided into an infinity of slices of thickness δx perpendicular to its length. He considers three consecutive slices at x, $x+\delta x$, $x+2\delta x$ at which the temperatures are y, y', y''. Then the rate of flow of heat into the middle slice from the first slice is

$$-K.4l^2(y'-y)/\delta x = -4Kl^2\,(\mathrm{d}y/\mathrm{d}x)$$

And the rate of flow of heat from the middle slice to the right-hand section is

$$-K.4l^2(y''-y')/\delta x = -4Kl^2\,(\mathrm{d}y'/\mathrm{d}x).$$

Therefore the net rate of gain of heat of the middle slice is $4Kl^2\,\mathrm{d}(\mathrm{d}y/\mathrm{d}x)$. The rate of loss of heat to air for the same slice is $8l\,\mathrm{d}x\,hy$, where h is coefficient of external conductivity. Therefore for a steady state

$$4Kl^2\,\mathrm{d}\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right) = 8l\,\mathrm{d}x\,hy,$$

that is

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = \frac{2h}{Kl}y.$$

One important aspect of this derivation of the equation of motion for the thin bar memoir is the way in which it becomes clear that $(\mathrm{d}^2y/\mathrm{d}x^2)/y$ must be positive in contrast to the earlier treatment which gave no grounds for rejecting a solution with a negative value for this ratio, leading to a trigonometrical solution in which one term could not be ignored as in the case of a positive value for the same ratio. Equally important was the explicit dependence of the constant of proportionality on the dimensions of the bar and on its coefficients of internal and external conductivity.

The treatment of the thin bar in the 1807 memoir gave the correct equation of motion and was based on the correct expression for the heat flux. But there was still one remaining imperfection originating from the treatment of heat flux as between consecutive *slices* of infinitesimal width δx as compared to the Prize Essay and the Analytical Theory where the flow of heat is always imagined across a geometrical section of zero thickness. In the case of the thin bar the transition from the standpoint of the 1807 memoir to the final, correct standpoint of the Prize Essay and the Analytical Theory is epitomized by the transition from the employment of the term *tranche* in the former work to that of *section* in the two latter works. What may well have represented Fourier's first use of *section* as opposed to *tranche* is contained in a letter[16] written to an unknown correspondent in the period 1809–10, one of the three[17] extant letters to an unknown correspondent or correspondents in which Fourier defended himself against the claim of Biot[18] and Laplace[19] that all those who had attempted to derive the equation of propagation of heat had run up against an analytical difficulty which could only be surmounted by following the method employed by Laplace in the annex on heat in his light diffraction paper of 1809.[20] The treatment given by Fourier in his draft paper was subject to this analytical difficulty, and it may have been this paper of which Biot had been thinking. But there was no justification for levelling the same criticism against the derivation of the equation of propagation of heat in the 1807 memoir. Fourier was therefore at great pains to bring out the difference between his former, erroneous derivation and that given in the 1807 memoir. To this end he gives a careful account of the original treatment in which he uses the *tranche* approach throughout and shows how its error resides in the assumption that the heat flow between *tranches* is proportional to temperature *differences*, as opposed to temperature gradient. This error had, of course, been corrected in the 1807 memoir. But in the letter he removes the remaining imperfection of the 1807 memoir and bases his treatment entirely on consideration of a *single* slice bounded by sections at x and $x+\delta x$ respectively. Now he considers[21] a *section* at distance x and denotes by z the quantity of heat traversing the given *section* from left to right in unit of time. Since the temperature of the bar is steady z must equal the quantity of heat lost in the same time over the whole surface area to the right of x. It follows that if x' is another section to the right of that at x, and z' is the corresponding value of z, $z-z'=$ quantity of heat lost per unit of time over the part of the surface contained between x and x'. If $x'=x+\delta x$ it follows that

$$\delta z = -\,chy\,\delta x,$$

that is

$$\mathrm{d}z/\mathrm{d}x = -\,chy$$

c being the circumference of a section of the rod perpendicular to its length. To determine the actual temperature distribution equation in the steady state it only remained to determine z.

An equally striking example of the transition from *tranche* to *section* is contained in two extensive marginal entries in the original text of the 1807 memoir itself. The first[22] is concerned with heat flux and talks throughout of heat flow across *sections*, and the second[23] is concerned with the equation of motion which is now obtained by equating the flux across a given *section* at distance x to the integral representing the total surface heat loss to the right of the given *section*. By differentiation of this equation the equation for the temperature distribution follows.

In the Prize Essay and the Analytical Theory there is no further use of three *tranches* either in the treatment or the derivation of the equations of motion. In the Prize Essay[24] the equation for temperature distribution for the thin bar is derived in the same way as in the second marginal entry[23] described immediately above. As for the method of derivation previously employed in Letter XIX, Fourier contents himself with noting that one 'obtains the same result by considering the equilibrium of heat in the *single*, infinitely thin slice contained between two *sections* whose distances are x and $x+\delta x$'.[25] In the Analytical Theory[26] he gives the integral approach first but now follows with the actual details of the alternative, 'sectional' derivation.

The derivation of the equation for steady temperature distribution in a thin bar was not only the first problem of the flow of heat in solids to be considered by Fourier but undoubtedly also the problem to which he first gave a definitive solution some time between the 1807 memoir and the Prize Essay. But the fact that there was a flaw in the derivation in the 1807 memoir did not prevent him from obtaining the correct equation for the thin bar. Also the method employed, unlike the faulty method followed in the 1804 draft paper, was now applicable to other and more important cases. Following the treatment of the thin rod the derivations of the equations for heat propagation in these cases all employed the three slice approach. The first problem considered after the thin rod, that of the motion of heat in a thin ring,[27] though effectively in three dimensions could be treated as one dimensional on the assumption that the ring was so thin that there was no appreciable variation in temperature over any section perpendicular to the central axis, the only variable being the distance x measured along this axis. Unlike the case of the thin rod, a non-steady state was considered. Previously, when considering the non-steady state in the Draft Paper,[28] Fourier had followed Biot's qualitative argument in his 1804 paper and had erroneously set the net rate of increase of heat in the element under consideration equal to the rate of change of *temperature*. This error was also remedied in the 1807 paper by the introduction of the specific heat capacity per unit volume of the substance, a quantity which was carefully defined earlier in the same work.[29]

In the next case treated, that of homogeneous sphere[30] heated to a given uniform temperature and then allowed to cool in a medium at zero temperature, the equation of propagation of heat could be written down by slicing up the sphere into thin spherical shells and assuming that the heat flow was necessarily everywhere in a radial direction. The same kind of *ad hoc* treatment making use of special symmetries could also be employed in the case of an infinite circular cylinder,[31] but in the case of an infinite prism[32] the equation of propagation of heat in the steady case required a full three-dimensional discussion. This time the division was by three sets of slices parallel to the co-ordinate planes yz, xz, and xy. Attention was directed to an infinitesimal cube situated at x, y, z and surrounded by six neighbouring cubes. In considering the flow of heat into the interior cube from the two cubes immediately above and below it relative to the yz co-ordinate plane, Fourier simply assumed this flow would be proportional to $\partial T/\partial x$ (where T is temperature), without giving any separate justification. This *lacuna* was first made good in the Prize Essay.[33] Apart from this the equation of propagation of heat in the steady case followed in the usual way as

$$\nabla^2 T = 0.$$

In the next case considered, that of the cooling of a finite cube, the additional term corresponding to a change in temperature led to the full general equation

$$CD(\partial T/\partial t) = K\,\nabla^2 T$$

for the propagation of heat in the interior of a continuous solid, where D was the density, and C the specific heat per unit of mass.[34] This general equation was then applied *ab initio* to re-derive the same equations for the sphere and the cylinder which had been obtained previously by *ad hoc* methods.[35]

The derivations of the equations of motion in cases other than the thin bar in the Prize Essay[36] and the Analytical Theory[37] differed from those given in the 1807 memoir in the replacement of three consecutive slices by a single slice, and in the corresponding shift in attention from transmission of heat *between* neighbouring slices to transmission of heat into a single element *across* its bounding surfaces.

In the 1804 Draft Paper the problems considered—a finite number of discrete bodies, a thin bar, and a semi-infinite strip, precluded the consideration of true boundary conditions involving the external conductivity. In the case of discrete bodies the question did not arise, whereas in the case of the thin bar the surface entered directly via the term hy into the equation of propagation itself; this was a result of the ideal assumptions concerning the thinness of the rod which made it possible to ignore any variation in temperature over a given section perpendicular to the length of the bar. In the case of the semi-infinite strip the assumption that the edges were at temperature zero likewise obviated the necessity of considering *physical* boundary conditions since it was only necessary to put the temperature equal to 0 when y equalled $\pm a$. This case was quite different from the situation at the surface of a sphere or a cylinder in *air* at temperature $T=0$. In the first case the temperature of the solid was held at $T=0$, whereas now it was the temperature of the surrounding medium which was held at $T=0$, and as a result there was an abrupt discontinuity in temperature at the surface. In the case of the semi-infinite strip the edges would have had to be in contact with infinite reservoirs at temperature $T=0$, whereas in the case of the temperature discontinuity the temperature of the air or other medium would have to be kept constant by keeping it moving at the surface as in Newton's original experiment.[38]

Fourier's uncertainty about the question of boundary conditions is indicated in the draft paper by the fact that in writing down the general equation of propagation in three dimensions he questions whether or not a term involving the exterior conductivity h should appear in the interior of the solid. This, he says, can only be determined 'by the results of experiments'.[39] In the 1807 memoir all such uncertainties have disappeared. If a term involving h remains in the equations for the thin bar or the thin ring this is a consequence only of their thinness and corresponds to the ideal assumption of no variation of temperature over the section. But in the case of a heated sphere allowed to cool freely in air at temperature zero, Fourier specifically comments in the text 'the value of the coefficient h is not found in this equation; but one first introduces it into the calculation when one expresses the conditions relating to the surface'.[40] The relevant surface conditions, namely, $K(\partial T/\partial r)+hT=0$ is duly given when the problem is considered later[41] with a view to obtaining an analytical solution relative to the given initial conditions. It is given without any fuss, and as though Fourier were unaware of its revolutionary nature, by simply expressing the flux of heat across the surface in two ways, first in terms of Fourier's own law of heat flux, and secondly in terms of Newton's law of cooling. Since Fourier's boundary condition does no more than tie together the flow of heat up to, but just beneath, the surface with the actual flow at the surface, it is surprising to find that it was one of the aspects of the 1807 memoir criticized by Biot and Laplace,[42] as we learn from the following passage:

> Unless I am mistaken myself the temperature of the extreme envelopes of a body are not as M. Laplace or he [Biot] represent them to be.[43]

Laplace's (and presumably Biot's) views on the question are given at the end of the section on heat in Laplace's 1809 paper on diffraction.[44] There[45] he assumes that the surface of a heated body rapidly reaches that of the surrounding medium, and that a law is then quickly established governing the rise of temperature within the body up to a certain maximum value U. The loss of heat is then proportional to U. This is opposed to the views of those (including Fourier and Newton!) who thought that the temperature of the surface was above that of the surrounding medium, thus breaking the law of continuity. But if Laplace had examined carefully the writings of Newton and subsequent writers on the subject, he would have seen that they all took care to state that the air surrounding the heated body was moving rapidly past it, thus maintaining a constant temperature. The rather wild nature of Laplace's hypothesis in this matter is in striking contrast with sober, simple, and *correct* condition formulated by Fourier, and provides another example of his superior physical intuition in this particular topic compared with that of Laplace, Poisson, or Biot.

Considerations similar to those employed in the case of a sphere sufficed to determine the boundary conditions in all the other cases considered in the 1807 memoir, and there is no change in this respect in the Prize Essay (or the Analytical Theory) except that now the boundary conditions are given immediately after the derivation of the interior equations of propagation instead of later when analytical solutions of these same equations are being considered. However, the Prize Essay[46] and the Analytical Theory[47] do differ from the 1807 memoir in containing the general expression for the boundary condition at any point of a solid of given shape which is equivalent to the modern expression

$$hT+K\,\nabla T.\mathbf{n} = 0,$$

where $\mathbf{n}$ is the unit vector in the direction of the normal at the point in question.

2. Solutions to equations

Although there was a superficial similarity between Fourier's mathematical treatment of the equations for the steady state and the non-steady state, there were in fact profound differences between the two kinds of problems both on the physical and the mathematical side which makes it necessary to consider them separately.

Steady state

Disregarding the mathematically trivial cases of the steady states for a thin bar and a thin ring the only steady state cases considered by Fourier were those of the semi-infinite strip and the infinite prism. In each case there were heat sources over which the temperature was held at a given fixed temperature, and heat 'sinks' at $y=\pm 1$ for the semi-infinite strip, and $y=\pm l$, $z=\pm l$ for the infinite prism, over which the temperature was artifically maintained zero.

Separation of variables alone in each case led to special trigonometrical solutions involving parameters whose possible values were then determined by the necessity of $T=0$ at the heat sinks. The complete solution was then expressed as a linear combination of the allowable special solutions with undetermined coefficients whose values were derived from the necessity for $T=1$ over the heat sources, at first by algebraic elimination (semi-infinite strip, Draft Paper)[48] and then by the far more convenient method of integration based on the orthogonal properties of the basic solutions.[49]

What does not seem to have been stressed is the highly artificial and cunning choice of $T=0$ at the heat sinks. In the case of the heat sources it would still have been possible to find the undetermined coefficients if one had had $T=$ any constant or even $T=T(y)$ for $-1<y<1$, in the case of the semi-infinite strip, or $T=u(y).v(z)$ for arbitrary u, v in the case of the prism, though of course it would have rendered the physical status of both these problems increasingly unrealistic. But in the case of the heat sink there was no choice other than $T=0$ if trigonometrical series were used. For the choice $T=0$ was the only one which could be satisfied both individually and collectively by all the special trigonometrical solutions and at the same time determine the allowable values of the undetermined parameters in these solutions. Ultimately Fourier could have dealt with a heat sink distribution of heat given by $T=\phi(x)$ by means of Fourier integrals subject to satisfactory behaviour of $\phi(x)$ at infinity. But when he first treated the problem of the semi-infinite strip such a treatment would have been beyond him. The innocent looking choice $T=0$, devoid of any physical significance for the temperature scale used by Fourier, had thus a hidden mathematical significance of tremendous importance.

Given the physical artificiality and idealization of the semi-infinite strip problem its essential significance was on the mathematical side, above all for its introduction of Fourier's use of trigonometrical functions expanded in the 1807 memoir into a general treatment of the problem of expressing an arbitrary function in trigonometrical series of sines or cosines or mixtures of both.[50] It was, of course, just the question of the adequacy of these trigonometrical functions for this purpose which constituted one of the two major criticisms of Fourier's 1807 memoir. This aspect of Fourier's work has already been given extensive treatment including a recent discussion by Gratton-Guinness of the bearing of the eighteenth-century string problem for Fourier's own work.[51] Relevant here is an interesting passage in a letter of Fourier which evidently constituted a reply to a charge of his having failed to refer to earlier works[52] on the subject of trigonometrical series:

> I transmitted this part of my work two years ago to M. Biot and M. Poisson who then knew the use I was making of it to express the integrals of partial differential equations in trigonometrical or exponential series: they did not point out to me that d'Alembert or Euler had employed these integrations to develop a trigonometrical solution. I was ignorant of the fact myself or I had entirely forgotten it; it was in attempting to verify a third theorem that I employed the procedure which consists in multiplying by cos ix dx the two sides of the equation
>
> $$\phi(x) = a_0+a_1\cos x+a_2\cos 2x+\cdots$$
>
> and integrating between $x=0$ and $x=\pi$. I am sorry not to have known the mathematician who first made use of this method because I would have cited him. Regarding the researches of d'Alembert and Euler could one not add that if they knew this expansion they made but a very imperfect use of it. They were both persuaded that an arbitrary and discontinuous function could never be resolved in series of this kind, and it does not even seem that anyone had developed a constant in co-sines of multiple arcs, the first problem which I had to solve in the theory of heat. It was also necessary to know the limits between which this development took place. For example it has to be realized that the equation
>
> $$x/2 = \sin x-\tfrac{1}{2}\sin 2x+\tfrac{1}{3}\sin 3x\cdots$$
>
> is no longer true when the value of x is between π and 2π. However, the second side of the equation is still a convergent series but the sum is not equal to $x/2$. Euler, who knew this equation, gave it without comment. It is very clear that if the method used to develop certain functions in trigonometrical series had been entirely exact it would have made known the limits between which the equations held true. Finally this development of a function in sines or co-sines of multiple arcs is only a particular case among those which I have had to treat, and these latter offered analytical difficulties of a very different order. It was necessary, for example, for determining the movement of heat in a cylindrical body to develop an arbitrary function in a series whose terms depended on a transcendental function given by a differential equation of the second order. I beg you, Sir, to be good enough to examine this part of my work which is really the only part worthy of your attention.
>
> I did not intend to denigrate the work which had been done before me by mathematicians as illustrious as Messrs. d'Alembert and Euler for I hold their memories in the deepest respect. But I have wished to make it clear that the procedure which they made use of was not adequate to solve the problems relating to the theory of heat.[53]

Non-steady state

The assumption of a normal mode time-dependence of the form exp (αt) was first made by Fourier in his treatment of the transmission of heat between a finite number of discrete bodies.[54] This, as he remarked, was 'a known method'[55] so that he evidently was familiar with at least this aspect of the treatment of the string problem by his predecessors in the eighteenth century. The same assumption formed the invariable point of departure for his consideration of all non-steady problems of the propagation of heat in continuous solids. Combined with the separation of the spatial variables among themselves and from the temporal variable there resulted separate ordinary differential equations in each of the spatial variables. The solution to all these equations were given in terms of trigonometrical functions involving undetermined parameters, with the exception of the cylinder.[56]

At this point boundary conditions had to be taken into account which with the exception of a thin ring took the form $K(\partial T/\partial r)+hT=0$. Once again this boundary condition was satisfied for each particular solution and led in turn in all cases (including that of cylinder) to transcendental equations for the undetermined parameters. However, unlike the case of the steady state in which the condition $T=0$ was necessary for trigonometrical solutions to be possible, these transcendental equations in no way restricted the particular solution in question. However their mathematical treatment, especially that of the reality of the roots, and especially that corresponding to the cooling of a sphere, proved troublesome and led to papers by both Fourier and Poisson even after publication of the Analytical Theory.[57]

Having determined, at least in principle, an enumerable infinity of allowable parameters, general solutions could then be written down involving arbitrary coefficients whose values could be determined from the arbitrary initial distribution of temperature for $t=0$ by multiplication and integration in which the vanishing of 'mixed' terms was guaranteed by the transcendental equations determining the boundary conditions.

A word needs to be said about the special case of non-steady propagation in a thin ring.[58] Here the allowable values of the undetermined parameters n in the spatial part of the solutions (viz. $\sin nx$) were determined by the necessity for the distribution of heat to be periodic of period $2\pi r$, where r was the radius of the ring. Since the corresponding solution with $\cos nx$ was equally permissible the general solution in this case involved a mixed expansion in terms of both sines and cosines, the coefficients being determined by integrations in terms of the initial distribution of temperature at time $t=0$. According to Fourier[59] he first derived these formula for the coefficients by the 'method of elimination', that is algebraically, and then independently by consideration of the results obtained previously for a finite number of discrete bodies arranged circularly between which heat could be communicated by a shuttle mechanism.[60]

The elucidation of the connection between the pure sine and cosine expansions valid in the region 0 to π of a function periodic with period 2π with mixed sine–cosine expansions in the region $-\pi$ to π was one of the few aspects in which the analytical theory marked a significant advance over the Prize Essay.[61] This exposition has not always been properly understood. For example, Kelland[62] made a number of errors because—as William Thomson[63] later pointed out—he did not realize that a sine/cosine expansion of a given function in the range 0 to π necessarily implied it was odd/even in the range $-\pi$ to 0 compared with the range 0 to π. More recently Grattan-Guinness[64] has made the surprising suggestion that:

> the purpose of this reasoning (that in the Analytical Theory) was clearly to avoid reliance on the integration term-by-term method of obtaining its co-efficients whose fallibility Fourier had seen all too clearly.

In fact, as the function is *necessarily* assumed to be periodic of period 2π then if it is given over the whole range $-\pi$ to π it will be determined everywhere else, and the fact that its Fourier expansion *must* involve both cosines and sines is to prevent it being either even or odd in the range $-\pi$ to 0 compared to 0 to π which is, of course, not necessarily the case. As for the coefficients of the various sine and cosine terms these are determined in the usual way by integrals as Fourier specifically states in direct contradiction to the statement of Grattan-Guinness.

One aspect of Fourier's work in the Analytical Theory of Heat to which little or no attention seems to have been given hitherto was his proof of uniqueness of solution for the heat conduction equation. It appears in section 280 of the Analytical Theory[65] immediately following his solution for the motion of heat in a ring. He gives an essentially step-wise proof: knowing the initial temperature distribution at time $t=0$ that at a short time Δt later follows uniquely, and from this that at time $2\,\Delta t$ and so on. This is obviously equivalent to the employment of a Taylor expansion in the time about $t=0$ of the form

$$\phi(t: x, y, z) = \phi(0: x, y, z)+t\left(\frac{\partial\phi}{\partial t}\right)_{t=0}+\frac{t^2}{2!}\left(\frac{\partial^2\phi}{\partial t^2}\right)_{t=0}+\cdots$$

each partial differential coefficient of order n with respect to the time $t=0$ being determined by means of the conduction equation in terms of the initial spatial distribution of the temperature.

A comparison with the Prize Essay and the 1807 memoir reveals no trace of uniqueness considerations in either of these two works. There can be little doubt that it was introduced into the Analytical Theory because of criticisms of Fourier's work by Poisson and Biot in 1815 and 1816.

Poisson's criticism deserves quotation in full:

> As the partial differential equation to which it corresponds is linear and has constant coefficients, one can also satisfy it by an integral composed of an infinity of exponentials of sines and cosines containing an infinite number of arbitrary constants: this integral is contained in the preceding one; but it would be difficult to decide *a priori* if it has the same degree of generality and if it can replace it identically, something which necessarily throws doubt and obscurity on all solutions deduced from this second form of the integral. M. Fourier, who did not go beyond a solution of this kind, remarks himself that it is similar to that which Daniel Bernouilli gave to the problem of vibrating strings; but it is well known that Euler, d'Alembert, and Lagrange, who occupied themselves at the same time with the same problem, and who differed among themselves on various points, were at one nevertheless in regarding Bernouilli's solutions as incomplete and less general than that containing arbitrary functions. This is not true of the formulas of M. Fourier: I am sure that all the results he obtains are correct; but

> against his analysis can be advanced the same objections as those advanced against that of Bernouilli and repeated in other similar cases.
>
> In general it seems to me that whenever an unknown quantity depends on a partial differential equation, and when its values should reduce in fact to a sum of particular integrals, the only way of disposing of all doubts and retaining for the mathematical certainty result is not to suppose in advance such a form for the unknown quantity, but to deduce it, on the contrary, from the general integral by a succession of direct and rigorous transformations. This is what I have attempted to do in this memoir . . .
>
> . . . I leave it to mathematicians to judge if I have attained the end that I have set myself.[66]

Biot echoed Poisson:

> . . . M. Fourier has since reproduced the same partial differential equation in a large work which has been crowned by the Institut of France. He satisfies it generally by an exponential integral which he applies to straight bars and to rings, both in the steady and non-steady states. In addition he has found an equation for the condition which must hold at the surface of an extended body when the heat excited in its interior comes to dissipate itself at this surface by radiation and contact with the air. But since exponential integrals do not in general allow in an applicable manner the discontinuities which are included in the general integral of partial differential equations, it remains to show that all possible methods of heating always produce in the end, and after a greater or lesser time, effects of this nature. This is what M. Poisson has achieved in a very fine memoir whose results I shall soon detail.[67]

Fourier's devastating reply to these criticisms of the form of his solution is contained in his unpublished Historical Précis.[68] He refers to Poisson's approach to the theory of heat based on a three-dimensional version of Laplace's solution to the one-dimensional heat-conduction equation containing an arbitrary function under the integral sign. Employing this type of solution Poisson reached the same results as Fourier. But this was necessarily the case. He illustrates this[69] by proving that the exponential solution for the motion of heat in a ring radius r whose temperature is a given function of position tends in the limit of $r \to \infty$ to the solution for a straight bar given by Poisson in terms of Laplace's solution. As he puts it more generally:

> The integral of the equation of the movement of heat can be presented in very different forms. The application to the theory of heat consists in discovering in the simplest way that which is most appropriate to the question proposed. One is assured that the solution is exact when the function of x and t which satisfies the differential equation represents the given initial state, and this solution is applicable when one deduces simply from the same function the numerical values of the temperature. The physical question remains imperfectly resolved if the second condition is not fulfilled. In general every expression of x, y, z, and t that satisfies the equation of the second order
>
> $$\frac{\partial v}{\partial t} = \frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}$$
>
> and which reduces when one puts $t=0$ to an arbitrary function $f(x, y, z)$ of the three variables x, y, z is the complete integral proposed. Such expressions are always identical, no one of them can be considered as more general than another, and in whatever manner they are obtained they certainly have the same range. If in solving diverse questions of the theory of heat one restricts oneself to deducing solutions of a certain form of the integral one makes the calculation infinitely more complicated, and it will be more difficult to discover these solutions when one treats entirely new questions.[70]

The point could not be put more clearly, and it only remained to supply a general proof of uniqueness as found in the Analytical Theory itself.

Notes

1. See especially Bose (2), Grattan-Guinness (1), (2), Jourdain (1), (2), Langer, Van Vleck.
2. Biot (1).
3. Ibid., p. 9.
4. He probably had in mind the works by Newton and Ingenhouss given in the bibliography.
5. Amontons.
6. Lambert.
7. Lambert, p. 184. Quoted in Mach, pp. 78–9.
8. Thus in the unpublished Historical Précis (fol. 157), Fourier wrote:

   > The researches of M. Biot had the same object as that of Amontons and of Lambert and they gave certain numerical values consistent with the law proposed by the latter. After that one would have expected that the works of these physicists would have been cited in M. Biot's work. We looked for this citation without success both in the work published in 1804 and in the new treatise of Physics. The author thus departs from an invariable usage and one founded on the most just motives.

9. Biot (1), p. 317.
10. The exact meanings of these terms were evidently not clear to Biot.
11. Biot (3), p. 669, n. 1.
12. Draft Paper, fol. 124–124v.
13. Ibid., fol. 108.
14. Ibid., fol. 108v.
15. 1807 memoir, art. 17. The development of Fourier's thinking on the question of heat flux is considered in chapter 9 below.
16. See below Letter XIX, Appendix, p. 307.
17. The other two are reproduced in the Appendix as Letters XVII and XVIII.
18. Biot (2), p. 336.
19. Laplace (3), p. 291.
20. Ibid., pp. 291–5. See below, chapter 9, p. 184 for an account of this method.

21. See below Letter XIX, p. 308.
22. 1807 memoir, fol. 38.
23. Ibid., fol. 40.
24. Prize Essay, pp. 217–18.
25. Ibid., p. 218.
26. Analytical Theory, pp. 51–2.
27. 1807 memoir, art. 23.
28. Draft Paper, fol. 125.
29. 1807 memoir, art. 15.
30. Ibid., art. 25.
31. Ibid., art. 26.
32. Ibid., art. 27.
33. Prize Essay, pp. 212 and 235.
34. 1807 memoir, art. 28.
35. Ibid., arts. 30, 31.
36. Prize Essay, arts. 11–14.
37. Analytical Theory, arts. 111–31.
38. Newton, p. 828.
39. Draft Paper, fol. 127v.
40. 1807 memoir, fol. 51.
41. Ibid., art. 98.
42. Also a criticism by Poisson referred to in Historical Notes.
43. See below Letter XVII, Appendix, p. 303.
44. Laplace (3).
45. Ibid., p. 294.
46. Op. cit., art. 15.
47. Op. cit., arts. 146–54.
48. Draft Paper, fol. 128–49.
49. A method referred to in the introduction to the draft paper and first employed in the 1807 memoir. See 1807 memoir, arts. 62–3.
50. 1807 memoir, arts. 50–74.
51. Grattan-Guinness (3), chapter 10.
52. See also Ravetz (2), for an account of these including bibliographical indications.
53. See below Letter XXI, Appendix, p. 318.
54. Draft Paper, fol. 109–20v.
55. Ibid., fol. 114v.
56. 1807 memoir, arts. 122–39. Fourier's treatment of this case by the introduction of the so-called cylinder or Bessel functions has already been exhaustively studied, most recently in Grattan-Guiness (3), chapter 16.
57. See especially Fourier's 1829 paper 'Remarques générales sur l'application des principes de l'analyse algébraique aux équations transcendantes', *Œuvres*, **2**, pp. 185–210.
58. 1807 memoir, arts. 76–94.
59. See Letter XXI, Appendix, p. 318.
60. See Prize Essay, p. 398 foot.
61. Analytical Theory, arts. 231–4.
62. Kelland, p. 64. The copy of Kelland's work consulted on loan from University Library, Glasgow has the following marginal comment: 'This is a mistake. Fourier formulae are quite right' W[illiam] T[homson]. Kelland's statement 'There can be little doubt to anyone who carefully examines the subject, that all Fourier series on this branch of the subject are erroneous' has been crossed out.
63. Thomson, W. 'On Fourier's Expansions of Functions in trigonometrical Series', *Camb. Math. J.*, **2**, pp. 258–62.
64. Grattan-Guinness (3), p. 281.
65. Analytical Theory, p. 299.
66. Poisson (3), p. 440.
67. Biot (3), p. 669 n. 1.
68. Op. cit., fol. 161v–162.
69. Ibid., fol. 161v.
70. Ibid., fol. 162.

9

EXPRESSION FOR THE FLUX OF HEAT IN SOLID BODIES

The familiar expression for the heat flux in solid bodies involving the partial spatial derivatives of the temperature distribution was probably taken very much for granted once the opposition of Biot and Poisson had been stilled by the presumed defection of Laplace to the enemy camp,[1] and little if any attention can ever have been given thereafter to what must always have seemed to the majority of readers of the Analytical Theory of Heat the rather tedious and longwinded justification given by Fourier of his expression for the heat flux.[2] But this is not an attitude which the historian of science can afford to take if he wishes to understand the process which leads to the creation of the Analytical Theory of Heat. On the contrary, he must put himself in the position of Fourier for whom it was of vital and anxious concern not only that the expression for the heat flux should be of the correct form—otherwise the theory itself would inevitably be incorrect—but also that it should be possible to justify this expression by deriving it from one of those fundamental simple principles or general facts to which the scientists of the eighteenth and early nineteenth century attached such overwhelming importance. By great good fortune there is sufficient material available to make it possible to follow in fairly close detail the gradual sharpening of Fourier's attitude to the heat flux from the original vague intuition that in the one-dimensional case the communication of heat between adjacent parts was proportional to a temperature 'difference', to the final careful and compelling justification for the general three-dimensional expression given in the Analytical Theory. One can thus come to appreciate both the great importance which Fourier attached to this element of his theory and the magnitude of his achievement in deriving and justifying the expression for the flux of heat.

The first essential step towards deriving an expression for the heat flux was the realization of the *necessity* for such an expression in the derivation of the equation for the propagation of heat starting with the simplest possible case of the thin bar. It was the failure to introduce such an expression which led to the inhomogeneity in the 'equation' derived by Fourier in the Draft Paper.[3] And the purely heuristic introduction of the term δx on the grounds that the conductivity of an infinitely thin slice would be infinitely great can perhaps be regarded as the first faint move in the direction of the introduction of the correct expression for the heat flux. A measure of the conceptual difficulties involved at this point is given by the fact that neither Biot nor Poisson seemed able to grasp this aspect of Fourier's approach, and as a result continued to harp on a supposed 'analytical difficulty' in Fourier's derivation—referring to the supposed existence of an inhomogeneity in the equation itself—as late as 1816.

Fourier had evidently hit on the correct temperature dependence of the expression for the heat flux before the completion of the Draft Paper, for in a check of his solution for the semi-infinite plate based on heat balance considerations,[4] he assumes that the heat flow per unit length across sections of the bar perpendicular to the x- and y-axis will be proportional to $(\partial T/\partial y)$, $(\partial T/\partial x)$ respectively. However, he gives no indication of any justification for the use of this result, and his first *proof* of the proportionality of heat flux on the spatial temperature derivative is found in the 1807 memoir in the process of giving a precise definition of heat conductivity within a solid body. There[5] he considers a prism of finite given cross sectional area and infinite length which has attained a steady state of temperature distribution in which the temperatures over two given sections *a*, *A* at a certain distance apart are 1 and 0 respectively. In that case it is 'easy to see' that the temperatures will decrease from 1 to 0 'according to the ordinates of a straight line'. For imagine the prism divided into an infinite number of equal slices by planes perpendicular to the axis. Each slice has a vanishingly small thickness and the temperature throughout it is assumed to be the same. According to hypothesis the difference of temperature between consecutive slices will be the same for *any* two consecutive slices throughout the length of the prism between *a* and *A*. At this point he makes an implicit appeal to the principle of Newton—already referred to explicitly in a marginal note[6] in his earlier discussion of radiation at the surface of a heat body—from which it follows that 'the quantity of heat which passes from one portion of matter to another depends (other things being equal) on the excess of the temperature of one body over the temperature of the second'.[7] The heat which flows between any two consecutive slices will therefore always be the same, and so the prism will conserve its actual state unchanged. He then considers a prism of the same substance with the same temperature difference between two sections *a*, *A* at half the distance apart of the earlier one. Now the flow of heat will be twice as great as before, since the temperature difference between consecutive slices in the second prism will be twice that in the first, and the quantity of heat transmitted is—again by Newton's principle—'other things being equal, independent of the absolute temperatures and proportional to the excess of temperature of one body over the other'.[8] Finally, in the general case of the division of a prism of the same material into slices of equal thickness, the heat flow will be proportional to the temperature difference between consecutive slices, and will therefore vary directly as the temperature difference $B-b$, and inversely as the distance $A-a$, between the ends of the prism. The heat flow may therefore be set equal to

$$-K.(B-b)/(A-a) \;=\; -K(\mathrm{d}y/\mathrm{d}x).$$

If $B=0$, $b=1$, and $A-a=1$ the quantity of heat which flows in unit of time across a given cross-sectional area will be K. This is the required precise definition of the conductivity K in terms of which the heat flux is now determined for one-dimensional flow in an infinite prism of the substance in question.

The case considered by Fourier up to this point was purely that of a steady distribution in a bar in which there was a linear fall off of the temperature from one surface to another. In a note at this point in the memoir he goes on to consider the more general case where the temperature distribution is no longer linear:

> We shall consider again the case where the different sections of the prism are subjected to fixed temperatures. Suppose that the section which corresponds to the abscissa a preserves the temperature b, that an intermediate section which corresponds to the abscissa x is maintained by some external cause or other at temperature y, that another section at distance x' is maintained at temperature y', and that it is the same for various other sections which being placed at distances $x'', \ldots, x''', \ldots$ by the effect of some cause or other preserve the temperatures $y'', \ldots, y''', \ldots$ finally that the last section at distance A preserve the temperature B. It follows from what has been said above that the solid subjected to these conditions will reach a permanent state in which the temperatures will be represented by the ordinates of a polygon. Therefore the flux of heat which traverses any section will not have the same value throughout the prism. It will not vary with the time for the same section, but it will in general be proportional to the tangent of the inclination of a side of the polygon.
>
> The preceding conclusion does not depend on the shape of the polygon, and it follows, therefore, that if every section of the prism were maintained by an external cause at a permanent temperature in such a way that the law of the temperatures was represented by the ordinates of any curve whatsoever of which x is the abscissa and y the ordinate, the quantity of heat which flows according to this assumption in a given time through a section of the prism which has reached a fixed state, will be proportional to the tangent of the inclination of the curve, and will have for exact measure $-K(\mathrm{d}y/\mathrm{d}x)$.[9]

Although the result obtained by Fourier for the heat flux in one-dimensional flow was correct, and led to the true equations for the propagation of heat for various cases beginning with that of the thin rod, the derivation of this expression was vitiated by the division of the prism into infinitesimally thin slices. At first sight this assumption appears to be no more than an idealization of the kind constantly employed in theoretical physics from Galileo onwards. Such idealizations, however, have to be physically realizable, at least in principle, and apart from the difficulty of accepting the notion of a slice of non-vanishing but infinitesimal thickness for which the temperature is everywhere the same, with the accompanying assumption of a temperature *jump* between successive slices, there is the quite unacceptable notion that *all* the heat transmitted to a given slice originates from the two neighbouring slices. This focusing of attention not on a *single* slice, but on a given slice in company with its two immediate neighbours, is found without exception in all the cases considered in the 1807 memoir and was in all probability inherited from the same 'three slice' aspect of the erroneous treatment of the thin bar in the Draft Paper[10] which in turn bears an obvious resemblance to Biot's consideration[11] of three successive 'points' on the bar. It may have been this aspect of Fouriers treatment of heat flow in a thin bar which gave rise to a criticism by Biot and others that the transfer of heat was assumed to be by immediate contact only. In Biot's case this particular criticism seems first to have appeared in print in his *Mercure de France* review of Prévost's book and then in more detail in his *Traité de Physique*.[12] Having discussed the condition governing propagation of heat in a bar and the ultimate attainment of a steady state in much the same qualitative way as in his paper of 1804, Biot continued:

> The algebraic enunciation of the preceding condition immediately furnishes a differential equation whose integral determines, for any given time, the temperature of each thermometer as a function of its distance from the source and the temperature of the latter.[13]

But the attempt to form this equation led to an 'inhomogeneity' which could not be removed as long as one supposed

> that each infinitely small material point of the bar only receives heat by contact from the point immediately preceding it, and only transmits heat to the point immediately succeeding it.[14]

It is important to note that Biot does not claim that the inhomogeneity difficulty is insuperable, but only that it cannot be removed by this special 'contact' hypothesis. Since this, as we have just seen, was the method employed by Fourier in his 1807 memoir, Biot is evidently making a veiled reference to that work.

However this immediate contact hypothesis is unacceptable to Biot for he continues:

> This difficulty can only be surmounted by admitting, as has been done by M. Laplace, that one and the same point is influenced, not only by those which

touch it, but by those which surround it at a small distance before and after. Then homogeneity is re-established, and all the rules of the differential calculus are preserved.[15]

The reference to Laplace was to his treatment of the conduction of heat in a bar given in an appendix[16] to his famous 1809 paper on double refraction. Having—as he thought—given a successful treatment of light based on intermolecular forces, he turned to the case of heat where he believed an application of the same methods should have led 'by a clear and precise manner to the true differential equation of motions of heat in solid bodies, and of their variations at its surface' and thus 'bring back the subject of heat into the domain of analysis'.[17] Considering that all this had been effected by Fourier some two years earlier in a memoir which was still being considered by a commission of which Laplace was a member, it is not surprising that Fourier reacted somewhat angrily to Laplace's contention.[18]

Before giving his own treatment Laplace argued[19] for its *necessity* by describing the inhomogeneity which arose in the treatment based on successive sections (as in Fourier's 1807 memoir) namely, that as the heats received by an 'infinitesimally thin' section of the bar from the sections to the left and right of it were both of the first order, their difference, which gave the total heat received by the intermediate section, would be of the second order, and this would not in a finite time produce a finite elevation of the temperature.

Laplace's method[20]—applied only to the case of a thin bar—consisted in considering two sections at the same distance S on either side of a section at position x. Then if u', u, and u_1 were the temperatures of the three sections, the heat received and communicated to the middle section would (by Newton's principle) be proportional to

$$k(u'-u)-k(u-u_1) = k(u'-2u+u_1).$$

It followed that the total heat received and communicated by the middle section, that is the flux across that section, was

$$\int_0^R k(u'-2u+u_1)f(S)\,\mathrm{d}S,$$

where the function $f(S)$ determined the way in which the heat action of one section on another varied, with their separation S, R being the radius of 'sensible action' of the heat. Setting $u'-2u+u_1 \simeq (\mathrm{d}^2u/\mathrm{d}x^2)S^2$ and replacing R by ∞ owing to the rapid decrease in $f(S)$ with increasing S, there resulted

$$k\frac{\mathrm{d}^2u}{\mathrm{d}x^2}\int_0^\infty S^2f(S)\,\mathrm{d}S = a\frac{\mathrm{d}^2u}{\mathrm{d}x^2}$$

where a was a constant.

Fourier refers to this implied criticism of his manner of deriving the equation of propagation of heat in a passage in one of two letters to unknown correspondents in which he strongly criticizes Biot for his implied criticism of his (Fourier's) memoir:

> As to the general principle about which M. Biot talks which consists in the fact that the molecules of bodies which are immediately adjacent to each other act the one on the other for the transmission of heat, I do not understand why one would wish to set it up as a new truth. It has seemed inconceivable to me that the action in question could be restricted solely to surfaces in contact, and it is evident, or so it appears to me, that each point of an element should act on every point of neighbouring elements. It is no less certain that when the surface of a body is heated the heat which dissipates itself into the colder air comes not only from the extremity of the surface, but also from points which are beneath it at a very small distance. I can assure you that I have often employed these considerations in my researches. But I have recognized very clearly that it was not necessary [to employ them?] for founding the theory of heat.[21]

The criticisms by Biot and Laplace of Fourier's method of deriving the equation of propagation of heat in a bar were evidently misdirected. For both authors ignored the fundamental fact that Fourier's derivation did not assume that the heat interchange across a given section was proportional to the temperature *difference* but to the *gradient* of the temperature. Nevertheless their criticisms may have had the effect of leading him to re-examine his use of successive slices of non-vanishing but infinitesimal thickness in his *derivation* of the formula for the heat flux. In any case, in the Prize Essay the transmission of heat between successive slices has disappeared, and in its place all transmission of heat is across mathematical sections within the solid. A possible shift from this use of *slice* to that of *section* can be seen in a marginal note to the 1807 memoir quoted above,[22] but the first full exposition of the correct treatment is found in part of the long letter of around 1809 to an unknown correspondent,[23] possibly Lagrange or Laplace. Nowhere else does Fourier bring out with such complete clarity the impossibility of determining the equation of propagation of heat in a thin bar—and by implication in other and more complex cases—without a knowledge of the exact expression for the heat flux *across a given section.* For[24] if z is the unknown expression for the heat flux as a function of the distance x along the bar, then consideration of the heat balance in the steady state for that part (slice!) of the bar between x and $x+\delta x$ gives $-\delta z = chy\,\delta x$, where c is the circumference of the bar, h its coefficient of exterior conductivity, and y the temperature. In the limit as $\delta x \to 0$ this gives the equation $\mathrm{d}z/\mathrm{d}x = -chy$. So that unless z was known as a function of the temperature y the equation of the propagation of heat would equally remain unknown. As Fourier put it in the unpublished Historical Précis with Biot in mind:

> One sees by that which precedes that without knowing the analytical expression of the quantity of heat transmitted one cannot form, and consequently one cannot enunciate or apply, the equation of the linear motion of heat.[25]

The remainder of the letter is largely taken up with the determination of the actual expression for z in the case of a thin bar. For this he imagines the solid contained between two infinite parallel planes held at different constant temperatures. Once the movement of heat has been determined in such a case it will be easy to apply the result to a slice of thickness δx. As in the 1807 memoir, but now in a much more sophisticated and satisfactory way, he proves that if the temperature decreases between the two planes 'as the ordinates of a straight line' then the temperature distribution will be steady. For consider any two intermediate sections m, n parallel to the bounding planes. He will show that the heat flow across m equals that across n. Therefore, the section between m and n will receive as much as it loses. It will therefore retain its state unchanged, and the same will be true of all other parts, and therefore for the solid as a whole. To prove that the heat flows across sections m and n are equal he considers a part AD of the solid which is divided at C into the equal parts, AC, CD so that m is the section through the midpoint of AC and n is the section through the midpoint of CD. By adding a *common temperature* to all the points of CD the mutual action of 'molecules' is unchanged, and therefore the heat flow is the same as before. But by a suitable addition the resulting temperatures of CD can be made equal to those of AC. Therefore the heat flow across m equals that across n. But m and n were *any* two intermediate sections. Therefore the heat flow across any section must be the same, and the solid will retain its steady state.

It remains to determine the value for this common flow of heat across any section. In order to do this he imagines a second, equal, solid whose bounding temperatures are in each case twice that of the first one. If p, q are two neighbouring points on either side of a given section in the first solid, and p', q' are the corresponding points on either side of the corresponding section in the second, then evidently the heat 'action' between p' and q' will be twice that between p and q. It follows generally that for any two solids of the same material and of equal thickness the heat flow across corresponding sections will simply vary as the ratio of the temperature differences between the bounding planes. From this it follows that the expression for the heat flow across a given section will be proportional to the difference of the bounding temperature divided by the distance between the two planes. The multiplying factor will naturally depend on the

conductivity of the material in question. For an infinitesimal slice δx whose end temperatures are y and $y+\delta y$ he deduces the heat flow across the section at x to be $-K(\mathrm{d}y/\mathrm{d}x)$. This is the required result from which the equation of propagation of heat in a thin bar immediately follows.[26]

In the Prize Essay[27] the derivation of the fundamental result for the heat flow in the one-dimensional case is essentially identical with that given in the 1809–10 letter. It is now prefaced, however, with some discussion[28] of the basic (Newtonian) principle on which the whole argument rests, namely that, other things being equal, the interchange of heat between any two molecules m, n is proportional to their temperature difference. In Letter XIX Fourier had already presented an ingenious derivation of this Newtonian principle based on the assumption that the transmission of heat between two 'molecules' will be unaltered if each temperature is increased by the same amount. For[29] let the 'quantities of heat' of the two 'molecules' p, q be U and V respectively, where $U-V=a$ is infinitely small compared with U or V. Suppose the quantity of heat sent by p to q equals $\phi(U, r)$ where r is the distance between the two molecules, and that that sent by q to p equals $\phi(V, r)$. The mutual action tending to change the temperature equals $\phi(U, r)-\phi(V, r)$ or $a\phi'(U, r)$. But if one adds the same constant quantity A to V and U there will be no change in the mutual action of the two molecules. Therefore, $a\phi'(U+A, r)$ is the same as $a\phi'(U, r)$. Therefore, $\phi'(U, r)$ is independent of U, and the mutual action between the molecules is simply proportional to the temperature difference, other things (including the distance) being equal, which is the Newtonian principle. He does not reproduce this argument in the Prize Essay, confining himself to citing some of the evidence in favour of the principle. Thus it would follow[30] from the principle that a common augmentation of the temperatures of all points of a body and its surroundings would make no difference to the flow of heat—a result so fully confirmed by experiments that it can be regarded as an 'invariable fact'. Also[31] that if a body sufficiently small for all its points to be regarded as at the same temperature were placed in a medium of given constant temperature the rate of loss of heat at any instant would be proportional to the temperature difference. This would lead to a logarithmic law of cooling against the time, a result once again amply confirmed by experiment. Or again,[32] if several points of a body in a medium held at temperature zero, were originally at temperatures α, β, γ and after a given interval of time at tempatures α', β', γ', then if they had been originally at temperatures $m\alpha$, $m\beta$, $m\gamma$ they would, after the same lapse of time as before, be at temperatures $m\alpha'$, $m\beta'$, $m\gamma'$. And so the final temperatures in the second case would be m times the final temperatures in the first case. Once again this is confirmed by experiment, and could only hold if the quantity of heat which passes from one molecule to another is proportional to the difference of the temperature between them. The agreement between observation and theory for the permanent temperatures of bars and rings, and for the movement of heat in the same bodies, and in those of spherical or cubical form, lent additional confirmation to the principle from which the theoretical results were deduced. This principle 'proposed by Newton, explained by Mr. Lambert of Berlin and accepted by all Physicists'[33] might require certain corrections in the light of further experiments, and it would then be easy to modify the form of the theory. But up to date, no precise observations had indicated the need for such a revision.

One respect in which the Prize Essay went beyond anything given in either the 1807 memoir or the 1809–10 letter was in the treatment of heat flow in the general case in which it could no longer be regarded as one-dimensional, as in the case of a solid bounded by two infinite parallel planes held at constant different temperatures. For this he first considers[34] the motion of heat in a prism in which the actual temperature is given by $\alpha x+\beta y+\gamma z$, the temperatures on the faces of the prism being maintained by some exterior cause at those given by the equation. He claims that this will represent a possible steady distribution of temperature. To see this it suffices to compare the flow of heat across two planes perpendicular to the direction of the z-axis at a distance c apart. The two molecules m, m' co-ordinates (x, y, z), (x', y', z') are infinitely close together above and below the first plane, and M, M', two similarly situated molecules with respect to the second plane, that is with co-ordinates $(x, y, z+c)$, $(x', y', z'+c)$. Evidently the distance between m, m', and M, M' will be the same, and from the equation of temperature distribution the temperature difference is the same in each case. Therefore the mutual action between M and M' will be the same as that between m and m'. This will be true of all corresponding pairs of molecules above and below the two planes. Therefore the heat flow across the second plane will equal that across the first, and the same will likewise be true for planes perpendicular to the x- and y-axis respectively. Therefore any interior portion of the prism bounded by six planes parallel in pairs to the faces of the prism will receive as much heat as it loses. Therefore no part of the solid can change its temperature, so that the original temperature distribution will be a steady one.

It remains to determine the heat flow across a section of the prism perpendicular to the z-axis. For this he considers[35] two molecules m and m' 'infinitely close' to the given section such that the line joining m, m' is parallel to the sections, and μ is a point below the section at an infinitesimal distance lying on the perpendicular bisector of m, m'. Then since the distances of μ from m and m' are the same, the action of m and m' on μ will be $q(v-w)$ and $q(v'-w)$ respectively, where q is a multiplying factor depending on distance between m, m', and μ and v, v', and w are the temperatures of m, m', and μ respectively. Therefore the total action of m and m' on μ will be $q(v+v'-2w)$. But this latter result would be the same as if the temperature distribution were $v=A+\gamma z$. This would be true for all pairs m, m', so that the *total* heat action *across* the section of the part above the section on that below the section would be the same as if temperature distribution were given by $v=A+\gamma z$. But in this case the result is known to be a heat flux $-K(\partial v/\partial z)$, and similar results will hold for sections perpendicular to the x- and y-axes respectively. As for the heat flow for *any* temperature distribution[36] $\phi(x, y, z: t)$ in a given solid, the temperature at a given time at point $x+\delta x$, $y+\delta y$, $z+\delta z$ infinitesimally close to the point x, y, z will be given by

$$\phi(x, y, z: t)+\frac{\partial\phi}{\partial x}\,\delta x+\frac{\partial\phi}{\partial y}\,\delta y+\frac{\partial\phi}{\partial z}\,\delta z.$$

This gives the same linear dependence of the variation of temperature in the immediate neighbourhood of xyz with respect to the co-ordinates δx, δy, δz relative to xyz as was assumed originally in the case of a finite prism. It follows that the heat flux per unit area over a section perpendicular to the z-axis will be $-K(\partial\phi/\partial z)$ with similar results for the other two co-ordinates. By these ingenious considerations Fourier made good in the Prize Essay a serious *lacuna* in the 1807 memoir where in his treatment of the full three-dimensional case of a rectangular prism he had simply assumed these results without adequate justification.[37]

Fourier evidently regarded his treatment of the heat flux in the Prize Essay as satisfactory since he added no new features to it in the Analytical Theory where the treatment[38] differs from that in the Prize Essay only in being spelt out in greater detail for the benefit, no doubt, of less gifted readers than in the case of the Prize Essay. However, at the time of the renewed criticism of his work by Poisson and Biot in 1815 and 1816 respectively, he brings out in rather more detail than previously his reasons for preferring his approach to that of Laplace—as advocated by Biot and Poisson—in which it was assumed that the propagation of heat within bodies takes place by radiation between 'molecules' as was the case outside bodies. To Fourier it seemed important 'not to give to the principle of communication of heat any hypothetical extension'. For the principle alone was sufficient to establish the mathematical theory of heat, and it was quite unnecessary

> to examine if the propagation is carried out by way of radiation in the interior of the solids, whether or not it consists in the emission of a special matter that the molecules interchange with each other, or if it results, like sound, from vibrations

of an elastic media. It is always preferable to restrict oneself to the enunciation of the general fact indicated by observation, which is no other than the preceding principle. One shows thus that the mathematical theory of heat is independent of all physical hypothesis; and in effect the laws to which the propagation is subject are admitted by all physicians in spite of the extreme diversity of their sentiments on the nature and the mode of its action.[39]

Notes

1. After the final controversy of the years 1815, 1816 and Fourier's letter to Laplace. See above chapter 7, pp. 157–8.
2. For example in Analytical Theory, chapter 1, sections 4 and 7.
3. See above chapter 8, pp. 164–5.
4. Draft Paper, fol. 145v.
5. 1807 memoir, art. 17.
6. Ibid., fol. 34.
7. Ibid., fol. 36.
8. Ibid., fol. 37
9. Ibid., fol. 38.
10. Draft Paper, fol. 124–124v.
11. Biot (1), p. 317.
12. Biot (3).
13. Ibid., p. 667.
14. Ibid., p. 667.
15. Ibid., p. 668.
16. Laplace (3), pp. 291–5.
17. Ibid., p. 290.
18. See above chapter 5, pp. 101–2, for an account of Fourier's angry reaction to the criticisms of Biot and Laplace.
19. Laplace (3), p. 291.
20. Ibid., pp. 291–4.
21. See below Letter XVII, Appendix, p. 303.
22. See above, p. 182.
23. See below Letter XIX, Appendix, p. 307.
24. Ibid., p. 309.
25. Historical Précis, fol. 158.
26. See below Letter XIX, Appendix, p. 309.
27. Prize Essay, p. 203 ff.
28. Ibid., pp. 200–3.
29. See below Letter XIX, Appendix, p. 312. By 'quantity of heat' he clearly intends *temperature*.
30. Prize Essay, p. 201.
31. Ibid., p. 201.
32. Ibid., pp. 201–2.
33. Ibid., p. 202.
34. Ibid., p. 209.
35. Ibid., p. 210.
36. Ibid., p. 235 ff.
37. 1807 memoir, art. 27.

38. Analytical Theory, chapter 1, sections 4, 7.
39. Historical Précis, fol. 158. Fourier's attitude, consistently maintained throughout all his work in heat, makes it unnecessary to give any consideration to contemporary views on the nature of heat as described, for example, in Fox.

10

MISCELLANEOUS TOPICS

1. Communication of heat between discrete bodies

CAREFUL readers of Fourier's Analytical Theory of Heat must often have been puzzled by the fact that the second largest section[1] in the whole work, that on the communication of heat between discrete bodies, seems at first sight to have precious little to do with the rest of the book. Admittedly, a closer inspection reveals two actual connections: in the first place it is shown[2] in this section that the result found by purely algebraic methods for a finite number of discrete bodies arranged circularly can be made to give in the limit the same result as that obtained in the preceding section by purely analytical methods for the case of a continuous ring, and this could be taken as providing an independent justification both for the latter result and, more significantly, for the equations from which that result was derived; in the second place, the same limiting process leads[3] to the analytical formula for the expansion of a periodic function $F(x)$ of period 2π given arbitrarily in the interval 0 to 2π in terms of a mixed series of sines and cosines of integral multiples of x. But these two results by themselves would scarcely justify the inordinate space given by Fourier in his treatise to this somewhat outlandish topic. The true explanation was probably a historical one, namely that Fourier's first researches in the theory of heat were on the subject of the transmission of heat between discrete bodies. The appearance of a long section on the same topic in the Analytical Theory of Heat can thus be regarded as an implicit monument to these earlier researches in much the same way as Newton's second proof of the law of centrifugal force in the *Principia* was a monument to his earliest researches in dynamics. Fortunately for historians of science, Fourier had a lively historical sense and no inclination to cover up his traces by the destruction of early drafts of his finished work, and it is therefore appropriate to find a section on the transmission of heat between discrete bodies in the early Draft Paper.

The treatment there,[4] as far as it goes, is identical with that given from the 1807 memoir onwards. Thus he first considers two equal bodies mass m of perfect conductivity at different temperatures a and b, and imagines a transmission of heat between them by means of an ingenious ideal shuttle mechanism consisting of an infinitesimally small section $\mathrm{d}m$ which moves to and fro in a fixed time $\mathrm{d}t$ between the two masses. By

entirely clear and straightforward assumptions he then shows that, to the first order of small quantities, the changes in the temperatures of the two bodies from their original values α, β at any time t as a result of a complete to and fro motion of the shuttle are given by

$$\mathrm{d}\alpha = -\frac{(\alpha-\beta)}{m}\,\mathrm{d}m, \qquad \mathrm{d}\beta = \frac{(\alpha-\beta)}{m}\,\mathrm{d}m.$$

Putting $k = \mathrm{d}m/\mathrm{d}t$[5] he obtains

$$\mathrm{d}\alpha = -\frac{(\alpha-\beta)k}{m}\,\mathrm{d}t, \qquad \mathrm{d}\beta = \frac{(\alpha-\beta)k}{m}\,\mathrm{d}t$$

and argues that k can be taken as a measure of the speed of transmission of heat, or reciprocal conductivity, between the two bodies since it increases as $\mathrm{d}m$ increases or $\mathrm{d}t$ decreases. Putting $\alpha-\beta=y$

$$\mathrm{d}y = -2(k/m)\,y\,\mathrm{d}t,$$
$$y = (a-b)\exp(-2kt/m),$$

where a and b were the initial values of the temperatures of two bodies, and it is assumed silently that a is greater than b. It follows that

$$\alpha = \tfrac{1}{2}(a+b)+\tfrac{1}{2}(a-b)\exp(-2kt/m),$$
$$\beta = \tfrac{1}{2}(a+b)-\tfrac{1}{2}(a-b)\exp(-2kt/m).$$

Therefore as the time increases both bodies tend to the same common temperature $\tfrac{1}{2}(a+b)$ which they would have acquired according to the accepted theory of specific heats if they had been put in direct permanent contact at the beginning.

Having given a complete solution for the case of two discrete masses, Fourier proceeds[6] to consider the general case of n separate equal masses arranged in a straight line and initially at arbitrary temperatures a, b, $c, \ldots$ in which transmission of heat takes place by the same shuttle mechanism between successive bodies as in the case of two bodies only. By precisely similar arguments he finds that the first-order changes of temperatures of the masses which at the beginning of a new round of heat transmissions were $\alpha, \beta, \gamma, \delta, \ldots, \psi, \omega$ are given at the end of a complete to and fro movement of the shuttles by

$$\alpha-\frac{\alpha-\beta}{m}\,\mathrm{d}m, \qquad \beta+\frac{\{(\alpha-\beta)-(\beta-\gamma)\}}{m}\,\mathrm{d}m, \ldots, \omega+\frac{(\psi-\omega)}{m}\,\mathrm{d}m;$$

He proceeds to look for a normal mode solution[7] of the form

$$\alpha = a_1\exp(ht), \qquad \beta = a_2\exp(ht), \ldots, \omega = a_n\exp(ht).$$

The corresponding equations for the coefficients $a_1, a_2, \dots$ are then

$$\begin{aligned} a_0 &= a_1 \\ a_1 &= a_1 \\ a_2 &= a_1(q+2)-a_0 \\ a_3 &= a_2(q+2)-a_1 \\ &\vdots \\ a_{n+1} &= a_n(q+2)-a_{n-1} \\ a_{n+1} &= a_n \end{aligned}$$

where

$$q = hm/k,$$

a recurrent series whose solution may be written in the form

$$a_m = A \sin mu + B \sin (m-1)u.$$

Putting $m=0$ and 1 gives $a_0 = -B \sin u$ and $a_1 = A \sin u$. Therefore

$$a_m = \frac{a_1}{\sin u}\{\sin mu - \sin(m-1)u\}.$$

On substituting this solution in the general term he then obtains $q = 2(\cos u - 1)$. Equating $a_{n+1} = a_n$ then gives $\sin nu = 0$ yielding n different eigenvalues

$$u_i = i\pi/h, \quad i = 0, 1, \dots, n-1.$$

The general solution of the original set of equations is then obtained by combining arbitrary linear combinations of the special solutions and he shows that as $t \to \infty$ this always tends to the mean initial temperature.

This general solution for the case of heat communication for a finite number of separate bodies is followed (as in the Prize Essay and the Analytical Theory of Heat) by the comment that as the number of bodies tends to infinity, $u \to 0$ and the term $\{\sin mu - \sin (m-1/u\}/\sin u$ tends to $\cos mu$.

At this point, however, there is a significant difference between the Draft Paper and the 1807 paper or the Prize Essay. In the draft he gives[8] an incomplete and unconvincing attempt to apply the above limiting solution to the case of a continuously heated *line* for which he suggests an equilibrium temperature distribution varying as $\cos x$ at distance x, a result which would appear to have been introduced in Fourier's handwriting after the original composition of the draft. He concludes:

> the analysis which we have employed could be used to determine the laws of the propagation of heat in bodies of several dimensions. But this transition from the solution which is appropriate to a finite number of bodies to an infinitesimal solution (if we can speak thus) requires complicated calculations.[9]

In the 1807 memoir[10] and beyond he repeats the analysis of the n body problem almost word for word and symbol for symbol up to the point where consideration is given to the passage to the limit of $n \to \infty$. He notes again that $u \to 0$ and $\{\sin mu - \sin (m-1)u\}/\sin u \to \cos mu$, but now he only considers the first term of greatest order depending on the time derived from $u_1 = \pi/h$ which gives the difference between the final temperature $(\Sigma\, a/h)$ and the actual temperature for large values of t. The discrete bodies can now be imagined to be arranged around the semi-perimeter of a circle, the angular position of body r being $r\pi/n$ (see Fig. 1). The body 'in the middle' (that is nearest to $\pi/2$) reaches the mean temperature most quickly, while all those on one side of it exceed the mean temperature, all those on the other side of it are less than the mean temperature, the time dependence of all being the same. He has evidently wisely given up the attempt of the Draft Paper to make a transition to the case of a continuous rod, while he is equally 'half way' towards considering the problem of a number of bodies spaced equally round a circle to which he immediately turns his attention.[11]

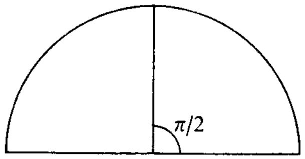


FIG. 1

Once again the transmission of heat takes place by the usual shuttle mechanism. But now there is a vital difference between the earlier treatment of the same number of masses in that the last mass communicates heat with the first. In other words the circle is closed, which makes a fundamental difference to the equations of motion and their solution. After the end of a further to and fro movement at time t, the first-order changes in the temperatures of the bodies which at the beginning of this movement were α_i, $i = 1, 2, \dots, n$ are given by

$$\begin{aligned} d\alpha_1 &= (k/w)(\alpha_n - 2\alpha_1 + \alpha_2)\, dt \\ &\vdots \\ d\alpha_i &= (k/w)(\alpha_{i-1} - 2\alpha_i + \alpha_{i+1})\, dt \quad i = 2, 3, \dots, n-1 \\ &\vdots \\ d\alpha_n &= (k/w)(\alpha_{n-1} - 2\alpha_n + \alpha_1)\, dt, \end{aligned}$$

where w is the mass of the shuttle and $k = w/dt$. The same normal mode solution $\alpha_i = b_i \exp(ht)$ is attempted as before which once again yields a recurrent series. The solution of this series can be expressed in one of n different forms

$$\left.\begin{aligned} b_{i,j} &= \sin iu_j \\ &= \cos iu_j \end{aligned}\right\} \rightarrow \alpha_{i,j} = b_{i,j} \exp(h_j t)$$

where

$$u_j = 2\pi(j-1)/n, \quad j = 1, 2, \ldots, n,$$

and

$$h_j = (2k/m)(\cos u_j - 1).$$

Any linear combination of the normal mode solutions is also a solution giving finally a most general solution:

$$\alpha_i = \sum_j (A_j \sin(i-1)u_j + B_j \cos(i-1)u_j) \exp\left\{-\frac{2kt}{m}(1 - \cos u_j)\right\}.$$
$$i = 1, 2, - n$$

To complete the solution it remained to determine the values of A_j, B_j, $j=1, 2, \ldots, n$, in terms of the initial values $a_1, a_2, \ldots, a_n$ of $\alpha_1, \alpha_2, \ldots, \alpha_n$. By an elementary though rather subtle argument he shows[12] that contrary to appearances there are only n different constants to be determined. These he obtains by setting the time equal to zero, multiplying each equation by an appropriate sine or cosine term, and adding, when all the sums on the right-hand side go out except the term involving the constant whose value is to be determined.

After considering two particular examples of no great importance, he proceeds to consider[13] the passage to the limit of infinitely large n carried out in such a way that $nm = 2\pi$ where m is the mass of each body. In place of separate masses he sets elements of length δx. The initial temperatures $a_1, a_2, \ldots, a_n$ become an arbitrary function of x where x is the distance along the arc. The following substitution is then set up:

n	m	k	a_i	i	α_j	j
$2\pi/\delta x$	δx	$\pi h^*/\delta x$	$\phi(x)$	$x/\delta x$	$\psi(x, t)$	$x/\delta x$

After some straightforward reduction including the replacement of sums by integrals this leads to

$$\alpha_i \rightarrow \psi(x, t) = \frac{1}{2\pi}\int \phi(x)\,\mathrm{d}x + \sum_{j=1}^{\infty} \frac{1}{\pi}\left\{\left(\int \phi(x) \sin jx\,\mathrm{d}x\right) \sin jx \right.$$
$$\left. + \left(\int \phi(x) \cos jx\,\mathrm{d}x\right) \cos jx\right\} \times \exp(-j^2\pi g t)$$

---

* h is the value of k when there are only two bodies. See Fourier's discussion of this on fol. 138 of the 1807 memoir.

Putting $h\pi = K$ gives identification[14] with equations already obtained for non-steady motion in a thin ring based on purely analytical considerations, provided—and Fourier omits to point this out—the exterior conductivity is set equal to zero, i.e. provided there is no exterior radiation. For Fourier this identification showed that it was not necessary to have recourse to the analysis of partial differential equations to determine the propagation of heat in a ring: one could solve the problem for an infinite number of bodies and let the number tend to infinity. According to Fourier this approach had a clarity which was peculiar to it and which directed the first researches'.[15] It brought out the 'separateness' of the particular values satisfying the partial differential equation which made up the general solution.

He notes[16] finally that on putting the time equal to zero in the general equation the formula obtained is that which he had already obtained for the decomposition of a function arbitrary in the interval 0 to 2π and periodic of period 2π into a sum of cosines and sines of multiple arcs.

2. Terrestrial heat

Fourier published three papers on the subject of terrestrial heat. The first was published in the Prize Essay of 1811[17] and in company with the treatment of radiant heat was one of two substantial additional sections in that work compared with the 1807 memoir. The other two papers on the same subject were published in 1820[18] and 1824[19] respectively. The latter work was largely expository in character and added nothing essentially new. It will not be considered separately from the first two which for convenience will be referred to as papers I and II respectively.

On several occasions Fourier maintained that from an early stage he regarded the problem of terrestrial heat as one of the most important which could be treated by the Analytical Theory of Heat and even one which he had had principally in view in establishing the theory.[20] In the introduction to paper I Fourier lists the various effects to be considered. In its diurnal motion, and its passage round the sun, the surface of the earth experiences a variation in temperature due to the effect of the sun. These two motions together produce periodic movements in the temperature at any given point of the surface. Observation shows that these oscillations rapidly die out at quite a short distance beneath the surface where the temperature becomes effectively constant. On the other hand, this constant temperature is different for different latitudes, an effect due to the inclination of the axis of the earth to the ecliptic. There are therefore two problems to be considered. The first is concerned with periodic changes in temperatures at a point of the surface. The second is concerned with changes in temperature from one latitude to another. Fourier considers these two problems separately. In the first place he considers[21] the problem of temperature variation in a vertical line given that the surface point is subject to periodic variation. And in the second case[22] he considers the problem of variation in temperature with latitude under the surface envelope of the earth due to the existence of the poles, that is, due to the fact that, regardless of small variations, the temperature at the north and the south poles is always extremely low, whereas that nearer the equator is always much higher.

To consider the first problem Fourier takes the equations of motion of the movement of heat in a sphere derived earlier in the Prize Essay,[23] and ignores the term containing the reciprocal of the distance u from the centre. This approximation will of course only be true at very great distances from the centre, but it will be justified in this particular problem since he is considering a sphere, the earth, of a very great radius. When this term has been dropped it follows that the equation of motion

$$\frac{\partial v}{\partial t} = k\frac{\partial^2 v}{\partial u^2},$$

is that for a line or an infinite prism. He now looks for a solution to this equation which is periodic in the temperature.

He suggests[24] the solution

$$v = a.\exp(-gu).\cos(2g^2kt-gu).$$

It is easy to check that this in fact does satisfy the equation. Likewise for sine in place of cosine. This solution must be periodic in the time, and if θ is the period of the variation in question then we must have

$$2g_r{}^2k\theta = 2r\pi \quad (r \text{ integral})$$

The general solution is obtained by combining all such special solutions for all allowable values of the g's, including $g=0$:

$$v(t, u) = a+\sum_{r=1}^{\infty}\exp(-g_ru).\{a_r\cos(2g_r{}^2kt-g_ru)+b_r\sin(2g_r{}^2kt-g_ru)\}.$$

Evidently all non-constant terms fall off rapidly with increasing distance below the surface. So that at a short distance one can confine oneself to the first non-constant term. The coefficients of the various terms are easily obtained by supposing $v(t, u=0)=\phi(t)$ is known and then in the usual way multiplying by an appropriate trigonometrical term and integrating over the period of the variation. It follows[25] from this that the constant term is equal to the mean temperature at the particular point of the surface. It is this mean surface temperature which the temperature in the interior rapidly attains with increasing distance below the surface owing to the rapid fall off of all the other terms.

In order to compare theory with experiment it would be necessary to insert particular values for the interior conductivity. He takes[26] the case of iron for which substance these parameters have been determined by experiments based on the Analytical Theory of Heat, namely with a ring and with a cooling sphere. By comparing the results obtained this leads to an approximate value $K=3/2$ for iron.[27] The values for the specific heat C and D the density are approximately $5/24$ and 7800 respectively. Inserting these values he finds that at a depth of 2·3025 metres and assuming a value for θ equal to 1440 minutes (that is for the diurnal variation) then the value of $\exp(-g_1u)$ is about $1/100$. Consequently at a depth of 2·3025 metres the diurnal variations are very small. In the case of the annual variations for which $\theta=365\times1440$ it is easy to see that the variations are practically insensible at a depth of about 60 metres. As for the earth itself, whose interior conductivity is much less than that of iron, the variations would penetrate to much smaller depths both for the annual and the diurnal variations, and this in fact is found to be the case. And thus the observations which had been known for a long time are explained in terms of the theory. As Fourier puts it: 'If these facts had not been known they would have been deduced as simple and obvious consequences of the general equation which we have put forward.'[28] He then goes on to consider the question of heat loss at the surface and restricting himself to the first of the periodic terms by straightforward and obvious calculations based on the expression for the heat flux he deduces that regardless of particular values of the parameters in question the heating of the surface commences one-eighth of a year before the temperature of the surface has reached its mean value, and the cooling of the surface begins one-eighth of a year after the temperature of the surface has again fallen to its mean value. For the particular case of iron, he also calculates the approximate amount of heat which passes in the course of half a year from the atmosphere to the interior of the earth over a given area of one square metre, and finds that it would be equivalent to that which would melt about 2856 kilograms of ice or a column of ice having a base area of one square metre and a height of 3·1 metres.

He now turns[29] to consider the quite different problem of the steady distribution of temperature in the interior of the earth due to the existence of the poles, that is due to the unequal heating of the surface of the earth by the sun.

He assumes that the temperature at any point of a given sphere is a function only of its distance (y) from the axis, and its distance (x) from the plane of the equator. In terms of these variables the steady-state equation becomes:

$$\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{1}{y}\frac{\partial v}{\partial y} = 0.$$

He shows that a particular integral of this equation is given by

$$v = \cos nx \int_0^{\pi} \exp (ny \cos r)\, \mathrm{d}r$$

where the parameter n is undetermined. The general solution is then obtained by a superposition of all possible particular solutions for different possible values of the parameter n. He studies the heat balance corresponding to this particular result, showing that the heat at any particular point flows perpendicularly to the parallel towards the poles, and that this loss of heat is exactly compensated by a flow of heat inward towards the axis. In general therefore the heat penetrates by parts near the equator and is dissipated at the poles.

In the introduction to paper II[30] Fourier goes over previous ground sorting out the various problems which go to make up the total problem of terrestrial heat. He explains how the problem of terrestrial heat can be divided up into three parts:

1. The action of the sun's rays produces oscillations in the surface layer. Below this the temperature is constant in a vertical line to a great depth and equal to its mean value at the surface multiplied by a decreasing factor involving the distance from the surface. During part of the year the earth loses heat to space and during part of it it gains it back again.
2. The motion of heat in the interior, that is away from the surface layer, consists of a slow flow—very much slower than the periodic changes—from the equator inwards and then upwards towards the poles. This was the second problem treated in paper I.
3. There is also a flow of heat due to the primitive store of heat in the earth. This corresponds to the secular cooling of the earth. It is evidenced (according to Fourier) by an increase of temperature as one descends deeply into the earth. It is this effect which is considered in paper II.

The idea is to approximate to the surface of the earth, or a particular region of the surface of the earth, by an infinite slab at whose free end there is a surrounding medium corresponding to the air at temperature zero. Initially the temperature distribution in the slab as a function of the distance u from the free end is given by an arbitrary function $F(u)$. The problem is to find how the temperature changes with the time. His solution[31] to this problem is as follows:

$$v = (2/\pi) \int_0^{\infty} \frac{\exp (-p^2Kt/CD)}{p^2+h^2/K^2} \left\{\frac{h}{K} \sin pu + p \cos pu\right\} \times \mathrm{d}p \int_0^{\infty} \left\{\frac{h}{K} F(\alpha) - F'(\alpha)\right\} \sin p\alpha \,.\, \mathrm{d}\alpha,$$

where p is a variable of integration, and h is an exterior conductivity.

He then investigates a number of special cases. In the first case he assumes that the temperature is constant and equal to a value b up to a depth A and thereafter is zero. In the second case he assumes the temperature is b everywhere up to an infinite distance. In the second case he investigates the variation of the temperature at the surface. By means of an ingenious transformation of the integral, he shows that for large values of the time t the surface temperature is approximately given by the formula[32]

$$v = (b/h)\sqrt{(CD/\pi Kt)}$$

He notes that exactly the same approximate formula would be obtained from the solution for a sphere when the radius is very large and for large t.

Once again it is impossible to make a proper comparison between theory and observation since the values for the parameters in the case of the earth are unknown and in any case there is reason to believe that at great pressure these equations would have to be altered. But by taking the values for iron one can get an idea of the correct order of magnitudes. The paper ends with a number of 'consequences'[33] all concerned with the primitive heat of the earth and its gradual loss by radiation at the earth's surface. If there had been no such primitive heat then the temperature at great depths would either be constant (if the permanent heating of the earth by the sun were completed) and otherwise would decrease. The fact that the temperature actually increases at great depths argues powerfully in favour of the existence of a primitive heat in the earth. An important factor in the cooling of the earth is the actual temperature of surrounding space disregarding the heat of the sun. The excess, v, of the surface temperature of the earth over that of surrounding space has a necessary connection with the rate of increase of temperature with depth at the surface, $(\partial v/\partial x)_{x=0}$, namely,

$$K(\partial v/\partial x)_{x=0}+hv = 0.$$

For iron, an increase of one degree in 30 metres would correspond to the temperature of the surface being $\frac{1}{4}$ degree above that of surrounding space. Lacking parameters for this earth the excess of its surface temperature over that of surrounding space can only be estimated roughly but it is in any case very small. From the theory it is possible to deduce a formula for the time of cooling of the earth in terms of the rate of temperature decrease at the surface and the original temperature of the earth, and also a formula for the rate of cooling of the surface temperature in terms of the time of cooling and the rate of decrease of temperature with distance at the surface. From this latter formula it appears that the rate of cooling at the surface is now excessively small and in any case less than 1/57 600 of a degree per century.

The smallness of the residual effects due to the primitive heat of the earth are in striking contrast to the much larger effects produced by changes in surface conductivity due to natural and human causes, the height of the sun, presence of waters, direction of winds, etc. It is these accidental effects which Fourier considers to be responsible for the difference of climates in the two hemispheres. On the other hand, in spite of the smallness of the observed effects due to a residual primitive heat of the Earth it still leads to a vast loss of heat by radiation at the surface and may still be associated with a very elevated temperature at the centre.

Fourier ends this paper by contrasting the paucity of observational material on the values for terrestrial parameters with the certainty of the Analytical Theory of Heat from which all consequences relating to the earth must be derived and which is independent of any supposition regarding the actual nature of heat itself.

Paper III,[34] in which Fourier is inclined to ramble from one topic to another, and which is lacking in any definite structure, is largely an exposition in general non-mathematical terms of the results obtained in the two earlier papers. It does, however, give a much more detailed discussion of the notion of interplanetary temperature.[35] He suggests that the existence of a temperature of interplanetary space different from absolute zero is due to heat reaching the solar system from the innumerable stars surrounding it. If these stars were absent, so that only the sun and the planets were in the skies, then the phenomena would be very different from those observed. Thus when the sun went down the temperature at the surface of the earth would suddenly drop to absolute zero. The slightest changes in the distance of the sun or the eccentricity of the orbit of the earth about the sun would produce major changes in the climate. The fact that these changes do not occur is due, according to Fourier, to the existence of an interplanetary temperature different from absolute zero.

3. Radiant heat

Fourier published a total of five papers[36] on the subject of radiant heat. The first, and much the most important, of these was given in sections 89–100 of the Prize Essay. The other papers published at various later dates are concerned largely with a further exposition of the ideas contained in the Prize Essay or with the discussion of explanations of experimentally observed results, and add little new to the original paper. They will only be referred to insofar as they clear up certain obscurities in that paper. In the second part[37] of his Historical Précis Fourier traces the historical background of the experimental work in the subject preceding his own theoretical investigations in the Prize Essay. Among other works he cites certain by Leslie, Pictet, and Prévost. Probably Prévost's work was the most important for Fourier since it contained one of the basic assumptions on which Fourier's own work was based, namely, that if a body surrounded by other heated bodies maintains its temperature unchanged it must receive as much heat by radiation from the surrounding bodies as it loses to them by its own radiation.

The Prize Essay paper is concerned essentially with two topics.

1. The law connecting the intensity of emission of radiant heat from a heated surface with the angle of emission.
2. Allowance for partial reflectibility and partial emissivity of radiation in the case of thermal equilibrium between a number of bodies in a hollow container whose surface temperature is given.

Fourier approached the law of emission from three separate standpoints. From the experimental side it had been shown by the experiments of Leslie that within the limits of experimental error the intensity of heat radiation emitted from a given surface varied with the sine of the angle of inclination of the radiation to the surface. From the theoretical side the law could be approached in two different ways. In the first place, one could attempt to derive it from the experimentally observed fact that in equilibrium the temperature of a body always took up the same value as that of its surrounding container. Fourier based his derivation[38] of the law here on the additional assumption that the *total* heat radiated per unit time from an element of surface, area S, temperature a, was aSh where h would be a constant characteristic of the surface in question. He then introduced an angular dependence of the radiation emitted by the introduction of a function $F(\sin\phi)$ so that if *all* the radiation were of the same intensity as that making an angle ϕ with the surface, the total radiation emitted per unit surface area would be $G=agF(\sin\phi)$, where g is another constant. It followed that the actual amount of radiation emitted per unit surface area would be $ag\int_0^{\pi/2} F(\sin\phi)\cos\phi\, d\phi$. So that $h=g\int_0^{\pi/2} F(\sin\phi)\cos\phi\, d\phi$.

At this point[39] Fourier made a considerable deviation to prove that if the intensity of emission were *in fact* proportional to $\sin\phi$, then bodies placed within different enclosures would ultimately take up the same temperature as the enclosure. However, if this law did not hold then in certain other cases this result would not follow.

Having thus provided some evidence in favour of the assumption $F(\sin\phi)\sim\sin\phi$ he returned[40] to the general case of a body within a given enclosure at a certain temperature. By considering two surface elements S, σ, one, σ, belonging to the body at temperature a, and the other, S, belonging to the surface of the container also at temperature a, he showed that the radiation sent from the first to the second would be

$$agS\sigma F(\sin\phi)\sin p/2\pi y^2,$$

while the radiation sent from the second to the first would be

$$agS\sigma F(\sin p)\sin\phi/2\pi y^2,$$

where y was the distance between the two elements and ϕ, p were the angles which the line joining the two elements made with S, σ respectively. For the heat sent from the first to the second to be equal to the heat sent from the second to the first it was necessary for $F(\sin p)\sin\phi = F(\sin\phi)\sin p$. For this to be true of all such pairs of elements the function $F(\sin\phi)$ would need to be proportioned to $\sin\phi$. This is the sine law, but it is clear that Fourier has not proved its necessity based on the single initial assumption—itself a physical fact—that in equilibrium the temperature of the body must be equal to that of the enclosure in which it is placed. In addition he has had to make a much more serious assumption of a detailed balance of radiation between any surface element of the body and any element of the surrounding surface. Nor can Fourier's assertion that 'it is easy to see that the equality of the two reciprocal actions is precisely that which constitutes the equilibrium of temperature'[41] be accepted.

The second method[42] of deriving the sine law of theoretical means was based on ingenious 'molecular' considerations. He supposed that all the interior layers of an emitting surface contributed to the emission of heat from the surface, but that owing to an extinction effect they contribute ever less as one proceeds away from the surface into the interior of the body. This results from the fact that any point within the body emits radiation with the same intensity in all directions, which falls off, however, with the distance from the point in question. It follows that radiation emitted in an oblique direction from a point within the body will have further to travel before reaching the surface and will therefore be less intense on emerging than will be the case for radiation directed perpendicularly to the surface. He puts this idea on a quantitative basis (see Fig. 2). He lets $\Phi(\alpha)$ express the contribution at a point O of the surface of the radiation emitted from a point Q within the solid at distance α from O. The assumption of a cut-off implies that $\Phi(\alpha)=0$ for $\alpha \geqslant a$. Then the whole line *om* (see diagram) contributes at O an intensity perpendicular to the surface of amount $\int\Phi(\alpha)\,d\alpha$. But for a point Q on Om at a distance α from O the contribution at P in an oblique direction ϕ will be $\Phi(\alpha/\sin\phi)$. Therefore the total contribution from Om at the surface in oblique direction ϕ will be

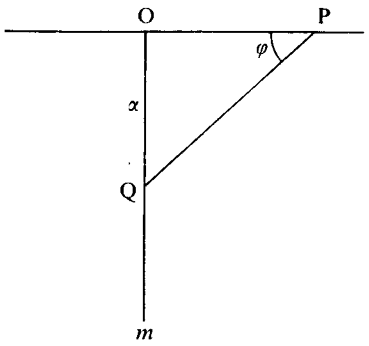


FIG. 2

$$\int_{\alpha/\sin\phi=0}^{\alpha/\sin\phi=a}\Phi(\alpha/\sin\phi)\,d\alpha.$$

Putting $\alpha/\sin\phi=\beta$ this gives[43]

$$\sin\phi\,.\int_0^a\Phi(\beta)\,d\beta$$

which is proportional to $\sin\phi$ as desired.

4. Movement of heat in fluids

Fourier presented a memoir[44] on the motion of heat in fluids to the Académie des Sciences and read an abstract of it to the Académie in the usual way. This was printed in the *Memoires* of the Académie along with notes on the subject found among Fourier's papers after his death by Darboux. The essence of Fourier's argument amounts to a correction of the normal equation of propagation of heat in solids, namely

$$C\,\partial\theta/\partial t = K\,\nabla^2\theta$$

by a term to take account of transfer of heat by conduction. Assuming that the amount of heat in a volume V of the fluid at temperature θ is CV where C is the constant value of the specific heat per unit volume, Fourier finds by the usual argument that the rate of gain of heat due to convection in an elementary box of side δx, δy, δz at x, y, z will be[45]

$$-C\left(\frac{\partial}{\partial x}(v_x\theta)+\frac{\partial}{\partial y}(v_y\theta)+\frac{\partial}{\partial z}(v_z\theta)\right)\partial x\partial y\partial z,$$

where v_x, v_y, v_z are the components of fluid velocity. Assuming that the transfer of heat by conduction and convection act independently it follows that the equation of propagation of heat is given by

$$C\frac{\partial\theta}{\partial t} = K\nabla^2\theta - C\left\{\sum_{x,y,z}\frac{\partial}{\partial x}(v_x\theta)\right\}.$$

Characteristically he derives the same result by slightly different considerations.[46]

5. Papers not on analytical theory of heat

Apart from his work on the analytical theory of heat, Fourier published only two papers on other topics in theoretical physics. The first was a paper[47] of 1798 on the principle of virtual velocities. In it Fourier attempts to deduce this principle from the principle of the lever which he in turn deduces from the assumption that three equal, and equally inclined, concurrent forces are necessarily, and self evidently, in equilibrium. This is the central object of the paper but there is also some additional discussion of the application of the principle of virtual velocities to the movement of fluids and the oscillation of systems of bodies about positions of equilibrium. A short study of this paper has been given by Costabel[48] who is of the opinion that apart from its undoubted interest and freshness of approach it would be impossible to assess its true originality, importance, or influence without a careful historical study of the whole subject including the contribution of Fourier's predecessors and contemporaries.

The other published paper[49] on theoretical physics was on the subject of wave motions in elastic laminae. Fourier does not concern himself here with the derivation of the basic equation, and the paper is of purely mathematical interest.

Notes

1. Analytical Theory, chapter IV, section 2.
2. Ibid., pp. 293–7.
3. Ibid., p. 297.
4. Draft Paper, fol. 109–23.

5. This argument and all subsequent uses of it by Fourier, is open to the criticism that although dt is the time for a single to and fro shuttle movement it is later regarded as a variable differential of the time for the purpose of integration. This difficulty can be avoided as follows. Let Δt be the *fixed* time for a to and fro shuttle movement. Then, as before,

$$\mathrm{d}a_{\Delta t} = -\frac{(a-b)}{m}\,\mathrm{d}m, \qquad \mathrm{d}b_{\Delta t} = \frac{(a-b)}{m}\,\mathrm{d}m.$$

For a time dt small compared with unit of time but large compared with Δt the change of temperature would then to the first order be

$$\mathrm{d}a = -\frac{(a-b)}{m}\,\mathrm{d}m.\frac{\mathrm{d}t}{\Delta t}, \qquad \mathrm{d}b = \frac{(a-b)}{m}\,\mathrm{d}m\,\frac{\mathrm{d}t}{\Delta t}.$$

If now we put $K/\mathrm{d}m = 1/\Delta t$ that is $\mathrm{d}m/\Delta t = K$ it follows that

$$\mathrm{d}a = -\frac{(a-b)}{m}K\,\mathrm{d}t, \qquad \mathrm{d}b = \frac{(a-b)}{m}K\,\mathrm{d}t,$$

and we only need assume this give a sufficiently good approximation to the differential equations.

$$\mathrm{d}a/\mathrm{d}t = -(a-b)K/m, \qquad \mathrm{d}b/\mathrm{d}t = (a-b)K/m.$$

6. Draft Paper, fol. 113 ff.
7. This, he notes, is the usual solution, so that he must have been familiar with at least this aspect of discussion of the string problem in the eighteenth century.
8. Draft Paper, fol. 121–3.
9. Ibid., fol. 123.
10. 1807 memoir, arts. 3–5.
11. Ibid., arts. 6–13.
12. Ibid., art. 10.
13. Ibid., arts. 95–6. Fourier only returns to the question of the passage to the limit after obtaining a solution for a ring by analytical means in arts. 76–94. His treatment of the limiting process is very beautiful.
14. Ibid., fol. 140.
15. Analytical Theory, p. 296.
16. Ibid., p. 297.
17. Prize Essay, arts. 80–8, 'Des températures terrestres et du mouvement de la chaleur dans l'intérieur d'une sphere solide, dont la surface est assujettie à des changements périodiques de températures', *Oeuvres*, **2**, pp. 3–28).
18. 'Le refroidissement séculaire du globe terrestre.' *Bull. des Sci. par la Société Philomatique de Paris* (1820), 58–70 (Extract in *Oeuvres*, **2**, pp. 271–88).
19. 'Remarques générales sur les températures du globe terrestre et des espaces planétaires'. *Ann. Chimie Physique*, **27** (1824), pp. 136–67 (*Oeuvres*, **2**, pp. 97–125).
20. See *Oeuvres*, **2**, p. 114.
21. Ibid., pp. 5–20.
22. Ibid., pp. 20–8.
23. Prize Essay, art. 44.
24. *Oeuvres*, **2**, p. 8.
25. Ibid., p. 11.
26. Ibid., p. 14.

27. Idem.
28. Ibid., p. 16 ff.
29. Ibid., pp. 20–8.
30. Ibid., pp. 271–3.
31. Ibid., p. 275.
32. Ibid., p. 277.
33. Ibid., pp. 282–8.
34. *Oeuvres*, **2**, pp. 97–125.
35. Ibid., pp. 106–8.
36. 'Note sur la chaleur rayonnante'. *Ann. Chimie Physique*, **4** (1817), pp. 128–45 (*Oeuvres* **2**, pp. 331–348); 'Questions sur la théorie physique de la chaleur rayonnante'. Ibid., **6** (1817), pp. 259–303 (*Oeuvres*, **2**, pp. 349–86); 'Resumé théorique des propriétés de la chaleur rayonnante'. Ibid., **27** (1824), pp. 236–81 (*Oeuvres*, **2**, pp. 387–424); 'Remarques sur la théorie mathématique de la chaleur rayonnante'. Ibid., **28** (1825), pp. 337–65 (*Oeuvres*, **2**, 425–49).
37. Loc. cit., fol. 163–8v.
38. *Oeuvres*, **2**, pp. 29–46.
39. Ibid., pp. 32–43.
40. Ibid., p. 43.
41. Ibid., p. 45.
42. Ibid., p. 54 ff.
43. Ibid., p. 57.
44. 'Mémoire d'Analyse sur le Mouvement de la Chaleur dans les Fluides'. *Mem. Acad. Roy. Sci.*, **xii** (1833), pp. 507–30. It is reproduced in *Oeuvres*, **2**, pp. 595–614.
45. *Oeuvres*, **2**, p. 606.
46. Ibid., pp. 607–9.
47. 'Mémoire sur la Statique contenant la Démonstration du Principe des Vitesses Virtuelles et la Théorie des Moments'. *Journal de l'École Polytechnique, Cah.* **5** (1798), pp. 20–60. *Oeuvres*, **2**, pp. 475–521.
48. Costabel, P. 'Fourier et le Principe des Vitesses Virtuelles'. *Sciences*, **3**, pp. 235–8.
49. 'Note relative aux Vibrations des Surfaces Élastiques, et aux Mouvement des Ondes'. *Bull. Sci. par la Société Philomatique* (1818), pp. 129–36. *Oeuvres*, **2**, pp. 257–67.

EPILOGUE: FOURIER THE MAN AND THE PHYSICIST

1. Fourier's achievement as a physicist

FOURIER was an experimental as well as a theoretical physicist. We know[1] that he spent two years prior to the publication of his 1807 memoir in repeating all previous experiments in connection with heat conduction, and adding some new ones of his own. His experiments were admittedly not creative in the sense of leading to new discoveries and theories in the manner, for example, of Faraday or Ampère. Instead he used them to confirm his theory, to give it 'an authority which one would have been inclined to refuse it, in a subject which is still obscure and subject to so many uncertainties'.[2] Nevertheless, one cannot refuse the title physicist to Fourier in the sense of a scientist who is involved with physics at first hand on one or other or both of the experimental or theoretical sides. For the term physicist does not exclude theoretical considerations, and these in turn need not necessarily be cast in a mathematical form; the example of Faraday, though very exceptional, is sufficient to establish this point, for nobody could deny that Faraday was a great theorist though he certainly was not a theoretical physicist in the usual, mathematical, sense of that term. Fourier, on the other hand was obviously, and pre-eminently, a theoretical physicist in just this sense. To assess his achievement as a theoretical physicist would therefore inevitably entail a judgment on his achievement as a mathematician. But this would fall outside the terms of reference of the present work in which I am only concerned with Fourier the mathematician in so far as this is necessary for an understanding of Fourier the physicist. The present section will therefore be concerned with Fourier's achievement as a (theoretical) physicist on the physical side, the mathematics involved being all of a trivial nature—as opposed, of course, to the ability to apply this mathematics, an entirely different matter.

In the light of what has been said above little or no account need be taken of the 1798 paper on virtual velocities. For this paper is a part of mechanics, contains no new principles, and is chiefly interesting for the ingenuity which Fourier displays in attempting to derive the principle of virtual velocities from other, and supposedly, more basic principles. In any case, a thorough investigation would be necessary[3] before any sort of reliable judgment could be made on the originality, importance, and possible influence of this paper. Fourier's work on elastic surfaces will also be ignored on the grounds that he himself played no part in the derivation of the basic equation of motion, his own contributions to the subject being purely on the mathematical side. The papers on terrestrial and radiant heat merit more careful attention, especially the latter. Those on terrestrial[4] heat are all based directly on the equation of propagation of heat in solid bodies. As such they fall essentially under the heading of mathematical physics or even applied mathematics. Nevertheless they are interesting from a physical point of view. Thus they provide useful evidence of Fourier's ability to deal with a problem which is essentially complex by reason of the number of physical factors involved including the interior heat of the earth, the loss of heat at its surface, the heat received from the sun, the effects of both the diurnal and annual rotation, the influence of the seas, and so on. Fourier's approach to this very complex problem was based on a number of extremely bold idealizations. These have been criticized as unrealistic, but at the same time they provide excellent evidence for Fourier's possession of what seems to have been one of the prime ingredients of true creativity in theoretical physics from Galileo onwards. Again, the papers on terrestrial heat display another attitude characteristic of the creative theoretical physicist, Fourier's awareness[5] that he was concerned with problems in which progress would ultimately depend on the collection of new observations and a continued interplay between theory and observations: the theory controlling the observations, and the observations leading to a gradual expansion and deepening of the theory. So that although his instinctive approach to this and other problems was through a very bold process of idealization, there was never any danger of him being carried away by the resulting theory. As regards physical problems, Fourier the mathematician was always very firmly under the control of Fourier the physicist who never lost sight of the need for a final appeal to observation.

More immediately relevant than his papers on terrestrial heat to Fourier's achievement as a physicist was his work on radiant heat.[6] Here there was no mathematical connection with, or use of, the basic equations of propagation of heat. This was a case of Fourier breaking entirely new ground by laying the mathematical foundations of a subject in which all previous work had been entirely experimental. His major achievement in the field was undoubtedly his derivation of Leslie's experimentally determined 'sine law' for emission of radiation at the surface of heated bodies. He gave two derivations[7] of this law, one based on a principle of detailed balance, the other based on 'molecular' considerations. Both derivations display Fourier's physical understanding and mathematical ingenuity in a flattering light. This work is certainly original and creative; what is quite uncertain at present is its importance historically by reason of its influence, if any, on successors such as Kirchhoff or Stefan. Given Fourier's great reputation in the mid-nineteenth century one would be inclined to assume that any work of his in radiant heat *must* have influenced all later work in the subject. But against this it must be remembered that there is almost nothing on radiant heat in the Analytical Theory of Heat itself, and it is not clear to what extent, if at all, his other published work was influential apart from the very special case of William Thomson,[8] Lord Kelvin, who seems to have had a peculiarly detailed knowledge of Fourier's work as a whole.

Of the cases considered so far the only one in which there was no doubt of an original, creative contribution by Fourier was that of radiant heat. But the physical aspect here was perhaps rather less prominent than the mathematical. Thus it must be remembered that in the case of the 'sine law' for emission of radiation Fourier was not searching for a new law but for a mathematical justification of one which had already been established experimentally. Also that he based the first of his two derivations on a physical principle—that of detailed balance—which had already been effectively given by Prévost. The situation was entirely different in the case of his formulation of the equations of motion of heat within and at the surface of solid bodies. Here there can be no doubt whatsoever of either the originality or importance of Fourier's achievement nor of its predominantly physical nature. It is on a study of the formulation of these equations that an estimate of the physical side of Fourier's achievement as a theoretical physicist must be based.

It was a profound physical understanding of the problem of the thin bar which led to the whole development of Fourier's analytical theory of heat. A detailed account had already been given of Fourier's treatment of this problem in the Draft Paper,[9] the 1807 memoir,[10] and in Letter XIX.[11] The one factor common to all three versions was the notion of the indestructibility or conservation of heat. This concept was found in Biot's 1804 paper, and before that—and unacknowledged by Biot—in Lambert, so that Fourier could evidently lay no claim to any originality here. Nor did his treatment of the problem in the draft paper show any real advance over that given by Biot except in a closer approach to physical reality by his replacements of Biot's 'points' by 'slices' of the bar. For although Fourier 'derived' an equation, whereas Biot only implied its existence, Fourier's derivation, as he himself makes plain in the Letter XIX,[12] was entirely unjustified. It was presumably the patently unsatisfactory nature of this derivation which stimulated Fourier to look for a better one, and this in turn inevitably led to what must be regarded as his most critically important and original single insight into the physical nature of the conduction of heat in solid bodies, namely, the concept of heat flux, and the concomitant realization that without a knowledge of the expression for the heat flux as a function of the temperature the problem of the thin bar—and by implication all other more complicated problems—would necessarily remain unamenable to rational treatment.

The notion of a flux of heat or other 'substance' as a rate of flow per unit time per unit area is such a familiar and central one in modern theoretical physics, that it is difficult if not impossible to assess the measure of originality involved in its original formulation by consideration of the concept itself. Contemporary evidence is fortunately available to make good this *lacuna*. Fourier's contemporaries, it will be remembered,[13] found it excessively difficult either to understand or to accept this concept. Thus Laplace, by any reckoning the foremost theoretical physicist among Fourier's contemporaries in France or elsewhere, certainly did not understand this basic element of the analytical theory of heat when he first encountered it as a member of the commission set up to report on the 1807 memoir, and the criticism of the derivation of the basic equations in the report on Fourier's Prize Essay proves that he still had not accepted it by February 1812. Biot and Poisson were even more obtuse than Laplace. As late as 1816 they were still insisting on the existence of an 'analytical difficulty' which could only be overcome by adopting Laplace's 'molecular' approach, whereas Fourier had proved—conclusively as it appears today—that it could equally be overcome by the use of his notion of heat flux.

Admittedly this evidence for the originality of the concept of heat flux is somewhat weakened by the fact that Laplace, Biot, and Poisson had each to varying extents an emotional blockage which stood in the way of a ready acceptance of Fourier's work, including the basic concept of heat flux. Not so, however, Fourier himself, and perhaps the best measure of his achievement in arriving at an absolutely clear formulation of the notion of heat flux and its function in the phenomena of heat conduction is provided—somewhat unexpectedly—by a comparison between his treatment of the thin bar problem in the 1807 memoir and in Letter XIX. This comparison, it will be remembered,[14] reveals a fundamental transition from a 'three slice' to a 'one slice' approach. On examining this transition it is clear that even at the time of composing the 1807 memoir Fourier himself had still not attained to a perfectly clear conception of heat flux. Admittedly there was an interchange of heat between consecutive 'slices'. But one could not really talk of a flux, since this is something which occurs not between two extended parts but across a geometrical section. And as Fourier is at pains to emphasize in Letter XIX[15]—possibly, as we have seen, in response to criticism of his treatment in the 1807 memoir—the heat in question must be thought of as originating not just in the parts of the bar immediately on either side of the section, but from other more distant parts as well, though the influence of these latter parts will, of course, be very small. The modern notion of heat flux therefore occurs for the first time in Letter XIX, and thereafter in the Prize Essay and the Analytical Theory of Heat. If we date Letter XIX to around 1810, it can then be said that some five years elapsed between the time that Fourier first entertained the notion of heat flux, and the absolutely clear exposition found in Letter XIX. Given the difficulty which Fourier himself experienced in clarifying this concept, Laplace, Biot, and Poisson must not be judged too harshly for their failure to welcome it with open arms, and in any case they must all be given some credit for having stimulated Fourier to make his formulation of the concept more precise and physically acceptable. All in all this is surely another example of one of those apparently simple, almost trivial, concepts in theoretical physics which nevertheless seem to require for their formulation the intervention of a Galileo or a Newton.

The realization of the need for the concept of heat flux led immediately to the need for an explicit, functional expression for this flux in terms of the variables of the problem. This was necessary for the true solution of the thin bar problem in the 1807 memoir,[16] and the proper expression for the heat flux in terms of the interior conductivity and the gradient of the temperature is found in that paper. However, just as Letter XIX contains both a more satisfactory treatment of the concept heat flux than the 1807 memoir and a much clearer exposition of the need for an explicit functional expression for this flux, so it also contains a far more satisfactory proof[17] of the actual expression for the heat flux than that given in the 1807 memoir. This new proof was in any case necessitated by the transition from the 'three-slice' to the 'one-slice' approach. The method followed was both interesting and ingenious, and was remarkable for the bold use of idealizations especially that of an infinite slab with steady heat flow as already found in the 1807 memoir. Noteworthy, too, was the manner in which the proof was based not on the Newtonian principle of heat interchange proportional to temperature difference, as in the 1807 memoir, but on the more fundamental principle—from which Fourier attempts to derive the Newtonian principle—that phenomena of heat conduction in bodies depend only on temperature differences between parts, and so will be unchanged if all temperatures are increased by the same amount. The somewhat wild nature of this idealization from a physical point of view needs no stressing. But once again it proves Fourier's flair for just the right sort of idealization required to simplify an essentially complex problem and make it amenable to mathematical treatment while simultaneously providing a solution yielding a good approximation to the actual physical situation in a wide range of cases.

An important, and original, aspect of Fourier's thinking on heat flux was his introduction of a precise definition of the interior conductivity, *K*.

This was given with great care in the 1807 memoir,[18] and it was an aspect which required no clarification or emendation in Letter XIX or in the Prize Essay. The first thing to be noticed about the definition is its complete novelty. To see this one has only to examine the welter of conflicting views on conductivity of heat held by experimentalists prior to Fourier.[19] In particular, the complete confusion which reigned as regards conductivity of a substance as measured by its ability to *conduct* heat, and its ability to *radiate* heat. Admittedly Biot[20] refers in his 1804 paper to the ratio of conductivity to radiation, but he gives no indication whatsoever of what precisely he means by either term. In a few pages in the 1807 memoir Fourier banishes all such confusion and uncertainty. But though Fourier's definition is perfectly clear it has simultaneously a peculiarly indirect character. It would be impossible to measure the value of the K for a given solid directly by means of this definition. Fourier, in fact, had introduced a parameter for which a numerical value was required if predictions were to be derived from the theory, but which itself could only be measured through application of the theory. Thus the definition of the internal conductivity K established a particularly intimate link between theory and experiment. K was a parameter whose value could never be given by the theory alone, only with the aid of experiment. But equally it was a parameter whose value could never be given by experiment alone, only with the aid of the theory. The obvious comparison here is with the mass parameter in Newtonian dynamics which necessitated a linkage between theory and observation in the application of the theory to specific cases. Unlike Newton, however, Fourier himself seems to have been well aware of this peculiar relationship between the conductivity and the theory.

What has just been said of Fourier's definition of interior conductivity applies *pari-passu* to his definition of surface radiating power[21]: it was utterly clear, entirely novel, dissipated previous confusion, and resulted in a necessary linkage between theory and observation. The definition of these two parameters in the 1807 memoir provides another striking example of Fourier's profound physical understanding of the true nature of the process of heat conduction. It also provides an equally striking example of his ability to express new physical concepts with admirable clarity and precision of thought and language.

Equally important, and complementary to, Fourier's definitions of interior and exterior conductivity was his *separation* of the process of interior conduction and exterior radiation of heat. Fourier, it will be remembered,[22] was at first uncertain whether or not a term involving the exterior conductivity, h, should always figure in the equation of propagation of heat within solids. The origin of this uncertainty was the justified presence of such a term in the equations for a thin bar or a thin ring. But when

writing down the *general* equation of heat conduction in two or three dimensions in the draft paper he also included a term in h.[23] At the same time he expressed his uncertainty as to whether the presence of this term was justified, and in the case of the semi-infinite strip he left it out altogether. But this was an artificial case in which the boundary condition did not involve h, since the edges of the strip were held at given fixed temperatures through contact with infinite reservoirs unaffected by any finite inflow or outflow of heat. However, in the case of a sphere originally heated throughout to a given temperature and then plunged in air held at a different temperature it was impossible to avoid a decision on the actual part played by radiation at the surface of the sphere. The outcome was the beautiful boundary condition expressing the flow of heat across a surface element in two ways: as a heat flux immediately within the surface, and as a flow of heat radiated immediately above the surface. In the 1807 memoir Fourier introduces this epoch-making boundary condition in such a casual and unassuming way as to give the impression that he did not himself realize what a brilliant and original contribution it was. But once again contemporary evidence is supplied by Laplace[24] whose own condition was not only inferior physically to Fourier's, but would seem to have been quite incapable of any precise mathematical formulation. Fourier's condition, on the other hand, was not only amenable to mathematical formulation, but through its mathematical treatment, first by Fourier himself, then by his disciples Sturm and Liouville, and after them by an army of other workers, it opened up the whole field of eigenvalues and eigenfunctions of such enormous importance for modern applied mathematics and theoretical physics.

The boundary condition for the cooling of a heated body immersed in an infinite medium maintained at constant temperature neatly epitomizes and sums up the various factors which underpinned the physical side of Fourier's achievement in the analytical theory of heat: a complete grasp of the underlying physical processes, a formulation of the corresponding physical concepts and their embodiment in definitions of compelling simplicity and clarity, an idealization of the problem at once bold and mathematically amenable, leading in turn to an elegant mathematical formulation of the process in question. There is nothing surprising or unfamiliar about these factors. What is uncommon—or what was at least in the past uncommon—is the simultaneous possession by one and the same individual of the necessary physical understanding, right philosophical approach, analytical powers, clarity of mind, and mathematical ability which seem essential for the fundamental creative acts which are at the root of all revolutionary advances in theoretical physics. Although the analytical theory of heat did not turn out to be as important from a physical point of view as Fourier had thought, and although the theory itself was eventually taken over by mechanics—albeit of the statistical variety—in direct contradiction to Fourier's unilateral declaration of independence in the Preliminary Discourse, nevertheless it is clear that the physical side of Fourier's achievement in theoretical physics must be rated of the very greatest importance if only because it made possible the creation of the analytical theory of heat with its very important influence in both pure and applied mathematics in the remainder of the nineteenth century and beyond. In any case, apart from the importance of the physical side of Fourier's achievement in theoretical physics, there remains the beauty and completeness of the achievement itself. Fourier's problem was at first a small one, in essence that of the conduction of heat in a thin bar. But the formulation he gave of it left nothing to be desired as regards clarity, completeness, and elegance. As presented in the Analytical Theory of Heat, and in the light of the supporting historical documents necessary for its proper understanding, it constitutes a wonderful example of creativity in theoretical physics, a rock-like foundation able to support the vast superstructive raised on it in the leisure hours of the Prefect of Isère by the mathematician Fourier.

2. The influence of Fourier's analytical theory of heat

Fourier's analytical theory of heat is largely mathematical in content involving the application of pure mathematical theorems and formulae to various thermal problems. But it does contain various physical elements, above all the derivation and justification of the basic equations of the propagation of heat, which alone would justify the application of the term theoretical physics to the work as a whole. It follows that the influence of Fourier's work must be considered under two main headings, its influence in mathematics and its influence in theoretical physics.

There is, of course, no necessity for a great and original work in theoretical physics such as Fourier's to have any influence whatsoever in either pure or applied mathematics. The contrary has almost invariably been the case. Thus few works either literary or scientific had a greater or more varied influence in eighteenth century Europe than Newton's *Principia*, but its influence certainly did not extend to mathematics, except in the negative sense of exerting a somewhat unfortunate influence on British mathematics through its use of synthetic rather than analytical methods. Or again, the contribution of Maxwell in electricity and magnetism, or Planck in radiation, or Einstein in relativity, were all enormously important and influential in theoretical physics, but were almost entirely derivative and uninfluential from a mathematical point of view. In fact Fourier's Analytical Theory of Heat was enormously influential in both pure and applied mathematics, more so, perhaps than any other important work in theoretical physics before or after up to the present day. When we ask the reason for this we find that the short answer resides in the fact that Fourier was the first person to give a reasonably thorough and detailed treatment of a whole class of problems based on a partial differential equation involving both temporal and spatial variables subject to non-trivial boundary conditions on both the temporal (initial) and spatial (surface) variables. In the process of dealing in succession with a series of problems of increasing complexity all based on the same (heat propagation) equation, he was faced in turn with a series of mathematical challenges to each of which he was able to give an adequate answer. His ability to do so proved his genius as a mathematician. His manner of doing so provided a harvest of original mathematical discoveries and techniques, which in turn provided a rich mine of material for many of the most important developments in pure mathematics in the rest of the century. At the same time the methods he had adopted for solving problems in the theory of heat proved immediately applicable to other branches of theoretical physics, so that his work was greatly influential also from the point of view of applied mathematics, all the more so because of his clarity of expression both literary and mathematical, and his great pedagogical skill born of a long and varied experience of the teaching of mathematics at various levels from that of the novices at St. Benoit-sur-Loire to the most brilliant students at the École Polytechnique. Fourier's work, in fact, was at one and the same time a treatise of great originality, and a text book of marvellous and compelling clarity.

Considerable attention has already been given to Fourier's influence in mathematics and there is no need to go over all the ground again in detail.[25] It seems to be agreed that Fourier's most important, and indeed revolutionary, contribution to pure mathematics was to the concept of mathematical function. His realization that the most 'unruly' and 'irregular' functions—even including those containing actual discontinuities in the modern as opposed to Eulerian sense—could be represented by trigonometrical functions, can be looked at in two ways. It could be regarded as a final and long-delayed resolution of the problem of the vibrating string in favour of the intuition of David Bernouilli against the views of Euler, d'Alembert, and Lagrange.[26] Alternatively, and perhaps more justly, one can regard Fourier's extension of the power of representation of trigonometrical series not as the closing of one chapter in the history of mathematics, but as the opening of a new and more exciting chapter in which the concept of function achieved its modern form through the successive contributions of Dirichlet, Riemann, Weirstrass, and others.[27] Certainly it is clear that Fourier himself perfectly understood the extraordinary nature and true importance of his discovery. Thus in the 1807 memoir he says:

> It is quite extraordinary that one can determine the value of the coefficients (of the various trigonometrical terms) although the given function may not be subject to any determinate law, and although one obtains the analytical equation of a curve composed of arcs of different kinds. One is led in this way to admit into analysis functions which have the same value whenever the variable has any value between two given limits; whereas if one substitutes in the two functions in place of the (previous) variable a number contained in another interval, the results of the two substitutions are different one from the other. The functions which enjoy this property are represented by different curves which only coincide in a certain portion of their extent and offer a peculiar kind of osculation which has not been considered hitherto.[28]

Of the other developments in pure mathematics which have been attributed to Fourier, perhaps the one which can be traced back most unmistakably to the Analytical Theory of Heat was the theory of orthogonal functions. Once again Fourier seems to have been well aware of the importance and generality of the new idea. Thus in Letter XXI (to Lagrange?) he states:

> Finally, this development of a function in sines or cosines of multiple arcs is only a particular case among those which I have had to treat, and these latter offered analytical difficulties of a very different order. It was necessary, for example, for determining the movement of heat in a cylindrical body to develop an arbitrary function in a series whose terms depended on a transcendental function given by a differential equation of the second order. I beg, you, Sir, to be good enough to examine this part of my work which is really the only part worthy of your attention.[29]

Other developments in pure mathematics which can be traced back with varying degrees of certainty to the Analytical Theory of Heat include the reintroduction and sharpening of the definition of the definite integral as a sum,[30] the notion of uniform convergence,[31] and the theory of infinite determinants.[32] Less plausible, perhaps, is the view[33] that Cantor was indebted to Fourier for the use of trigonometrical functions in the early development of his theory of point sets.

In applied, as opposed to pure, mathematics Fourier's work was equally influential. Particularly important here were the use of Fourier series and Fourier integrals as two of the prime tools in the solution of mathematical problems occurring in applied mathematics, the methods employed for the first time by Fourier (at any rate in a consistent way) for treating problems in applied mathematics involving partial differential equations subject to boundary and initial conditions, and Fourier's treatment of the full time-dependent conduction or diffusion equation. These methods, first consistently and *clearly* employed by Fourier in his Analytical Theory of Heats have become such a familiar part of modern methods in applied mathematics that it is difficult to realize how revolutionary and novel they were at the time of the publication of Fourier's book. No doubt an exhaustive dredge of all previous writings in the eighteenth and early nineteenth century in both pure and applied mathematics would show up some earlier uses of Fourier's methods and techniques apart from the known example of trigonometrical series. Nevertheless, there can be no question that the use by Fourier of all these methods was so consistent and so clear that their simultaneous publication in his work affected a revolution in applied mathematical techniques, and that thereafter they rapidly became accepted as standard methods.[34]

When we turn to consider Fourier's influence in theoretical physics we immediately notice a striking contrast with the cases of pure and applied mathematics. Whereas in the latter cases Fourier's most profound and original discoveries, especially in relation to trigonometrical and other expansions, had a direct, explicit, and conscious influence on later developments in pure mathematics, his most original achievements on the theoretical–physical side—his derivation of the correct heat flux expression[35] and the equations of the propagation of heat including the boundary conditions—seem to have passed without comment and to have had little influence either explicit or implicit on his contemporaries or successors once his theory had been generally accepted, for it must be remembered that with the exception of his use of trigonometrical expansions no aspect of his work had given rise to greater controversy[36] before the acceptance of his theory by Laplace had finally stilled the carpings of Biot and Poisson.

There would seem to have been two main reasons for this at first sight curious and paradoxical situation, the first a general one, shared with many other original developments in theoretical physics, the second more peculiar to the Analytical Theory of Heat. In the first case, Fourier's fundamental achievements on the theoretical physical side were largely ignored once the theory as a whole had been accepted because this is the almost inevitable fate of any successful theory in theoretical physics, and in direct proportion to the success of the theory. Thus, as opposed to his law of gravitation and his 'explanation' of planetary motions, Newton's development of the concept of force and his application of the second law of motion seem to have been undervalued by everyone in the eighteenth century including Newton himself—as witness his attribution[37] of the first two laws of motion to Galileo. The same could be said in large measure of Maxwell's derivation of his equations for the electromagnetic field, or of Einstein's formulation of the dynamical equations of motion in Special Relativity. In each case the theoretical physical achievement resided almost entirely in the original, creative, inductive process which led to the formulation of the appropriate mathematical equation governing the process in question. Insofar as the resulting theory was correct it was incapable of modification or extension as regards its basic structure, and to that extent was never influential directly but only indirectly through its application to other problems, that is in an applied mathematical sense. This is assuming, of course, that the theory in question was complete: insofar as Newton did not formally deal with rotating bodies in any of his published work[38] there remained original theoretical physical contributions to be made to the subject by Euler and others. Insofar as Ampère's contributions to electromagnetism were incomplete they stimulated further original contributions to the subject. But insofar as Maxwell's theory came at the end of a long line of previous investigations of which it was the final and complete crown it left little room for any further really creative developments on the physical side within the domain of classical physics. Fourier himself was probably well aware of his own achievement in deriving the correct equations of motion of heat, especially in the light of the controversy they had given rise to with Biot, Poisson, and for a time, Laplace. There appears, however, to be no evidence that any of the later admiration for his work was directed to this aspect of it, though allowance must be made for the possibility of an almost unconscious—and possibly very important—influence of Fourier's whole handling of the physical foundation of his theory, especially his definitions of the various new concepts involved in its formulation discussed in section 11.1 above.

There are, of course, good reasons for this tendency for the fundamental physical achievement in any original development in theoretical physics to be disregarded. In the first place, the finished work by itself usually gives little indication of the process leading to the final formulation of the basic equations[39] for the topic in question—for this, earlier drafts, often unpublished, are essential. In the second place, it is only comparatively recently, especially with the work of Koyré,[40] that historians of science have begun a fundamental reappraisal of the process of discovery in theoretical physics based on the growing realization that some apparently simple and hitherto neglected conceptual advances may actually have represented the most characteristic, original, and difficult steps in the creation of various branches of theoretical physics.

The other particular reason in Fourier's case why his achievement on the theoretical–physical side had so little direct influence was due to the very thoroughness and completeness of his formulation of the basic physical principles of the theory. Thereafter, there remained little for his successors to do but to apply Fourier's equation and methods to problems not considered by Fourier himself. In one obvious sense, of course, Fourier's work *was* influential in theoretical physics as a whole insofar as it represented the conquest of a branch of experimental physics by mathematical treatment. In this respect Fourier's success in the subject of heat encouraged others to attempt a like conquest by similar methods in other branches of physics. For example, George Greene, one of the very earliest British theoretical physicists to be fully aware of the significance and importance of Fourier's work, in the introduction to his Essay on Electricity and Magnetism instances the success of Poisson and Cauchy in applying Fourier's methods to the subject of water waves.[41]

Another respect in which Fourier's work was important was as a model of right method in mathematical physics. As Poincaré commented:

> Fourier's theory of heat is one of the first examples of the application of analysis to physics. Starting from simple hypotheses, which are nothing but generalized facts, Fourier deduced from them a series of consequences which together make up a complete and coherent theory. The results which he obtained are certainly interesting in themselves, but what is still more interesting is the method which he used to arrive at them and which will always be a model for all those who wish to cultivate any branch of mathematical physics.[42]

Another evident influence of Fourier's work in theoretical physics was his treatment of his problem of terrestrial heat,[43] which provided the starting point for later investigations, especially those of William Thomson.[44] It is possible, too, though to my knowledge unproven, that Fourier's work on radiant heat, especially his use of the principle of detailed balance to derive the sine law of emission,[45] may have influenced later work in that field also.

Account must finally be taken of possible influences of the Preliminary Discourse to Fourier's Analytical Theory of Heat. This differs from most other parts of the treatise in having effectively no antecedents in the Prize Essay or the 1807 memoir. Both these latter works have introductions, but they are almost exclusively concerned with the contents of the succeeding texts whereas the Preliminary Discourse ranges far beyond the bounds of the Analytical Theory of Heat to touch on general aspects of the philosophy of both mathematics and science. The reason for this greater generality of outlook can only be guessed at, but it could well have been due simply to Fourier's sense of occasion on publishing the final, printed version of his masterpiece and a felt need to preface it by some sort of scientific *credo* in the manner of the prefaces to the first and second editions of Newton's *Principia*, or of the introduction to Huygens's *Traité de la lumière*. As for the title itself, *Discours Préliminaire* as opposed to the more customary 'preface', it may have had overtones in Fourier's mind with such epoch-making and revolutionary works as the *Discours Préliminaire* of d'Alembert or that of Lavoisier in his *Traité Élémentaire de la Chimie*.

Absolute clarity of expression was one of the great virtues of all but the latest of Fourier's published work in some of which he becomes a trifle rambling and obscure, but in the Preliminary Discourse this clarity is somewhat surprisingly found in company with a rather confused structure—reminiscent of a similar lack of structure in the Introduction to the *Description of Egypt*—in which Fourier alternates between straight descriptive passages, philosophy of mathematics, philosophy of science, and expressions of opinion relating to his own work.

The descriptive passages serve much the same purpose as the introductions to the 1807 memoir and the Prize Essay. But they not only tell the reader what to expect in the body of the work, they also tell him something of Fourier's attitude to science in general and his own theory in particular. Thus, as might be expected from so convinced a Baconian as Fourier, repeated stress is laid on the utility of the theory for the civilian economy and the arts[46] apart from its application to the physical sciences including the great question of terrestrial temperature.[47] A measure of this severely practical approach is given by his emphasis on the necessity of the theory leading to numerical application 'a necessary condition of all research, without which one never reaches beyond useless transformations'[48]—a possible reference to the approach of Poisson in terms of a Taylor expansion in the time, which though mathematically equivalent to Fourier's approach was scientifically useless owing to the impossibly slow rate of convergence of the resulting series. For numerical applications the measurement of the basic quantities of thermal capacity, and interior and exterior conductivities was essential,[49] an enterprise which could only be successfully carried out by a union of theory and experiment which was equally vital for any further progress of the theory.[50] As to the analysis on which the whole theory was based, in a beautifully concise but complete manner he describes[51] how it consists of the general conditions governing the motion of heat, i.e., the equation of motion of heat, the accidental but continuing effects of the figures or state of the surfaces, and the non-durable effects of the original distribution of heat. He also refers to various problems not considered in the 'present work' including radiant heat, terrestrial temperatures, the comparison of theory with experiment, and the equations of the movement of heat in fluids.[52] All but the last of these had already appeared in the Prize Essay of 1811, and were to reappear in the published version of that work. Finally, as regards descriptive passages, and as befits a great scientist who had always a deep interest in the history of his subject, he gives a brief autobiographical account[53] of the historical development of the subject beginning with the treatment of the transmission of heat between separate masses.

In his references to mathematics Fourier makes the customary remarks on its universality, simplicity, and clarity: 'There cannot', he believes, 'be a more universal or simple language, one more exempt from errors and obscurities.'[54] The principal attribute of mathematics is clarity. She has 'no signs to express confused notions'.[55] More debatable was his belief that 'the profound study of nature is the most fruitful source of mathematical discoveries'.[56] Fourier's fellow mathematicians would have had to admit that this belief had worked exceptionally well in Fourier's own case. But some would have taken strong exception to Fourier's utilitarian attitude to mathematics agreeing with Jacobi that 'the only end of science is the honour of the human mind, and that consequently a question about numbers is worth as much as a question about the system of the world'.[57] All would have been agreed, however, on the striking way in which mathematics 'follows the same path in the study of all phenomena: interprets them by the same language, as if to attest the unity and simplicity of the plan of the universe, and to render even clearer this immutable order which presides over all natural causes'.[58]

As regards philosophy of science, Fourier reveals himself already in the introductory paragraph of the Discourse as a confirmed positivist:

> The primordial causes are unknown to us, but they are subject to simple and constant laws which can be discovered by observation and whose study is the object of natural philosophy.[59]

Elsewhere he refers to the small number of 'general facts' to which all thermal phenomena may be reduced, or to the possibility of deducing the 'principles' of the theory from a small number of

> primordial facts whose causes are not considered by mathematicians, but which they admit as resulting from ordinary observation and confirmed by experiments.[60]

On several occasions he refers to the importance of experiment and observations and their blending with theory. For example, no progress is to be expected in so complex a subject as terrestrial temperatures without many more measurements of the various observed effects. Nevertheless the theory itself will still play a vital part:

> the theory itself will direct all these measures and will assign to them their precision. There cannot be henceforth any considerable progress which will not be founded on these experiments; for mathematical analysis is able to deduce from general and simple phenomena expressions of laws of nature: but the special application of these laws to effects which are very complicated requires a long theory of exact observations.[61]

Finally there was his attitude to his own theory. Here again he brings out his strongly Baconian, utilitarian attitude to science in general and his own theory in particular with its 'multiple connections'[62] with civilian uses and technical arts. Most important, and I shall suggest most influential, was his dogmatic attitude to the 'independence' of his Analytical Theory of Heat, and the impossibility of a 'take-over' by mechanics: in spite of the impressive range of applicability of the principles of mechanics stretching from the movements of the stars, their shape, the equilibrium and oscillation of the seas, the harmonic vibration of air and sounding bodies, the transmission of light and the vibration of liquids—ample confirmation of Newton's homage to mathematics: '*ac gloriatur Geometria quod tam paucis principiis aliunde petitis tam multa praestet*'[63]—in spite of all this Fourier was of the opinion that:

> whatever may be the extent of mechanical theories, they do not apply to the effects of heat. These [effects] make up a special order of phenomena which cannot be explained by the principles of movement and equilibrium.[64]

On the other hand the 'new theories' explained in Fourier's work:

> were united forever to the mathematical sciences and rest like them on immovable foundations: they will retain all the elements they possess today, and will continually acquire further application.[65]

Now it must be confessed that with one exception to be discussed presently, none of Fourier's views on the philosophy of either mathematics or science sound particularly original, and in any case they are no more than a characteristically concise Gallic sketch as opposed to a more fully worked out and suitably obscure Germanic exposition. His attitudes to the nature of mathematics and its remarkable role in the interpretation of phenomena could have been original, but they have a flavour which is either markedly Cartesian—simplicity, clarity, universality—or which remind us strongly of the Great Book doctrine of Galileo as echoed by Newton, d'Alembert, Laplace, and a host of others. And although his belief that 'the profound study of nature is the most fruitful source of mathematical discoveries', had perhaps never been put in so memorable a form before, it was scarcely an original view; one finds exactly the same attitude, for example, with Laplace and Poisson.[66]

Likewise, his emphasis on facts could be paralleled many times in the writings of Maupertuis, d'Alembert, and others from the victory of the Newtonian camp in the 1730s onwards,[67] and it certainly represented the core of the philosophic attitude which dominated French scientific thought immediately before the Revolution as expressed, for example, in the writings of Lavoisier[68] and his disciples, or in those of '*idéologues*'[69] such as Cabanis or Destut de Tracy. Fourier would certainly have been exposed to this influence during his time at the Collège Montaign around 1786 when he could scarcely have avoided coming in contact with the writings of Condillac[70] which had contributed so largely to the strongly 'positivist' attitude of French science in the 70s and 80s.

Although there was a great deal of common 'Newtonian' ground among philosophically minded French scientists from Maupertuis onwards—an emphasis on observed facts, an aversion to hypotheses of a speculative, Cartesian kind frowned on by the implacable Newton, an appeal to the method of analysis and resolution and so on—there was nevertheless a striking amount of variation in their attitude to causes. Some, like d'Alembert and Laplace inclined towards a belief in a single, ultimate cause, itself unknowable but from which everything else would be derived, though Laplace had no false illusions about the likelihood of *finding* this cause, at any rate in the foreseeable future.[71] Others like Lavoisier[72] and his disciples took a much more positivist line, putting greater emphasis on facts and turning away from the search for causes as not only dangerous but unnecessary. A possible explanation of the origin or Fourier's somewhat surprising adherence to this second school is provided by his understandably hostile attitude towards Laplace's attempt in 1809 to derive the equation for the propagation of heat in a thin bar from 'molecular' considerations. It will be remembered that Laplace and Biot had claimed that this was the only way to surmount a supposed difficulty relating to incompatible terms in Fourier's quite different treatment. Although Biot had much the worst of the ensuing controversy, nevertheless Poisson and he renewed the same criticism in 1815 and 1816 respectively. In his unpublished Historical Précis completed in 1816 Fourier gave a considered reply to their criticisms and in the course of his arguments brought out more clearly than in any of his published writings the reason for his apparent aversion to first causes, at least as regards heat:

> It is not enough to allege that a physical hypothesis is necessary to surmount certain difficulties which would be insoluble without this explanation. Questions of this type are not decided by authorities. It is necessary again to base oneself on special reasons and positions. To us it seems more important not to give to the *principle of communication* of heat any *hypothetical* extension, and we think that this *principle suffices* to establish the mathematical theory. For the fundamental equations are demonstrated in the most clear and most rigorous manner without it being necessary to examine if the propagation is carried out by way of radiation in the interior of the solids, whether or not it consists in the emission of a special matter that the molecules interchange with each other, or if it results, like sound, from vibrations of an elastic medium. *It is always preferable to restrict oneself to the enunciation of the general fact indicated by observation, which is no other than the preceding principle.* One shows thus that the mathematical theory of heat is independent of all physical hypotheses; and in effect the laws to which the propagation is subject are admitted by all physicists in spite of the extreme diversity of their sentiments on the nature and the mode of its action.[73]

As opposed to his largely derivative views on the philosophy of science and mathematics, it does not seem possible to point to any very convincing precedent for the dogmatic, separatist attitude of Fourier towards his own theory expressed in the curious assertion:

> whatever may be the extent of mechanical theories, they do not apply to the effects of heat. These [effects] make up a special order of phenomena which cannot be explained by the principles of movement and equilibrium.[74]

This is perhaps the most puzzling statement in the Preliminary Discourse, and one which goes clean against Fourier's habitually careful, level-headed, and almost uniformly correct judgements in matters scientific and mathematical. It thus calls for some explanation, especially in the light of its possible influence on Auguste Comte, and through him on French philosophical attitudes to Science in the second and third quarters of the nineteenth century.

There seem to be at least two possible explanations of this attitude: the first on technical, mathematical grounds, and the second on largely personal grounds having little to do with either physics or mathematics.

The Analytical Theory of Heat developed by Fourier was based mathematically on a general equation of propagation of heat together with initial and boundary conditions. The latter changed from one problem to another; the former might take different forms depending on the coordinates chosen or on special symmetries or other features of the heated bodies under consideration, but the basic equation was always the same. It was, as it were, though Fourier himself does not express it in this way, an invariant feature of his theory, just as the form of the equations of motion was an invariant feature of Newtonian dynamics or—and more relevant—just as the motion of continuous bodies, as in the propagation of sound or in the vibrations of a flexible string, were governed by 'invariant' partial differential equations which could themselves be derived under certain plausible simplifying assumptions from the more basic Newtonian equation of motion.

Now both the equations of propagation of heat and the propagation of waves in air or strings were of the second order as regards the spatial variables. But here the similarity between the two ceased: whereas the dynamical equations, such as that of d'Alembert which must have been particularly familiar to Fourier, were of the second order in the time derivative, Fourier's equation for the propagation of heat was of the first order, and there was no example then known to science of a dynamical equation referring to continuous bodies with a first order partial derivation in the time. It could—one is inclined even to say it must—then have seemed to Fourier that his theory, with its entirely different type of equation, could never be brought under the sway of mechanics all of whose branches were based on Newton's equation which in every case led to a partial differential equation of the second order in the time. If this was Fourier's argument—and it is difficult to believe that it could have escaped him—then one must have every sympathy with his judgement. It *is* surprising that, contrary to Fourier's belief, the theory of heat can be brought under the sway of dynamics but only, of course, if one is prepared to introduce statistical or quantum statistical mechanics.

The other possible explanation of Fourier's attitude is more speculative, and can be regarded in any case as at most a minor contributory factor towards his final attitude, though it may well have played a more important part at an earlier stage, namely the fact that during the whole of Fourier's most active work in the theory of heat from around 1805 up to the publication of the analytical theory in 1822 the subject of mechanics (in the sense of dynamics) was entirely dominated by Laplace. If, as I shall suggest later,[75] this may have explained the otherwise somewhat curious absence of any contribution by Fourier to the subject of celestial dynamics, it might *a fortiori* explain, if only at the subconscious level, his reluctance to see his own theory taken under Laplace's Newtonian umbrella, more especially as he had had to fight off an attempt by Laplace to take over the whole subject for himself, or for his disciple Biot, by his derivation of the expression for the heat flux from 'molecular' consideration in the annex to his paper on diffraction.

As regards the question of a possible influence on Comte as opposed to an 'explanation' of the statement itself, the facts are simple and not open to dispute. Comte was acquainted with Fourier who attended some, at least, of his second course of lectures on the positivist philosophy. Little is known beyond that of the relations between the two men,[76] but regardless of Fourier's views of Comte—and during the increasingly reactionary reign of Charles IX a vaguely revolutionary figure like Comte would have been inclined to instil a mild alarm into the liberal-minded but very cautious Fourier of the last years—the fact that Comte dedicated the published version of his lectures to Fourier leaves little room for doubt on his attitude to Fourier and this is explicitly confirmed by a passage in the 'exposition' where Comte claims that Fourier's researches on heat supply striking verification for his own views:

> In fact, in this work, of which the philosophical characteristic is so eminently positive, the most important and precise laws of thermal phenomena are discovered *without the author having once enquired about the intimate nature of heat*[77] [italics added].

Many passages could be cited which prove that Comte extended

Fourier's antipathy to enquiring into the intimate nature of heat to all phenomena:
Thus:

> Today all discerning intellects recognize that our real studies are rigorously restricted to the analysis of phenomena in order to discover their effective laws, that is to say their constant relations of succession and similarity, and that these studies can in no way concern the intimate nature of phenomena, nor their cause, either first or final, nor their essential method of production.[78]

Finally there are certain passages in Comte which remind one strongly of the separatist attitude of Fourier towards the theory of heat for example:

> Because of the variety and complication of its phenomena physics will be greatly inferior to astronomy whatever its future progress may be. In spite of all arbitrary suppositions optical phenomena will always form a category *sui generis* necessarily irreducible to any other: a light will always be heterogeneous to a movement or a sound. In default of other motives, physiological considerations oppose themselves invincibly to such a confusion of ideas by the unalterable characteristics which profoundly distinguish the sense of sight whether from the sense of hearing or from that of contact or pressure. If such radical separations could be arbitrarily effaced according to certain gratuitous hypotheses, be they more or less ingenious, it is impossible to see where such aberrations would be halted.[79]

It may be, of course, that the separatist attitude to physics evinced by Fourier and Comte represented some deeper and more fundamental attitude of French scientists which would still have been influential in French theoretical physics in the absence of the expression of this attitude by Fourier and Comte. One is reminded, for example, of the equally dogmatic separatist attitude towards species of Georges Cuvier, Fourier's close colleague as the biological permanent secretary of the Académie des Sciences during the whole of Fourier's tenure of the mathematical secretaryship in the period 1822 to 1830. In any case, the whole question of the role of positivist attitudes in the apparent decline of certain branches of science—including theoretical physics—in France from around 1830 onwards is still very much an open one.[80] And while it may be true that Fourier's influence in this respect in France may not have been an altogether happy one, there are good reasons for believing that elsewhere Fourier's whole work, including the Preliminary Discourse, exerted an entirely healthy influence. This seems to have been particularly true in the case of William Thomson, Lord Kelvin, a life-long devotee of Fourier, through whom Fourier influenced the whole development of nineteenth-century theoretical physics in Britain culminating in Clerk-Maxwell's work in electromagnetism.[81]

3. Fourier the man and the physicist

From his letters, his scientific and mathematical writings, the reports he edited as a member of the Académie des Sciences, and the *éloges* he was responsible for as the permanent mathematics secretary to that body, we get a clear impression of Fourier's intelligence, incisive clarity of thought, originality, and sound common sense. In his personal correspondence there is evidence of more human qualities: a sense of humour, interest in others, generosity, genuine affection on occasions, especially in certain letters to Bonard and in the enigmatic letter to Dr. l'Herminier.[82] All these impressions are confirmed by contemporary accounts such as those of Jomard and Cousin which also speak of his great personal charm, his fabulous memory, his persuasive eloquence, his pleasant old-world manners, his wide interests, liberal views and genuine love of humanity. The account of Geoffroy Saint Hilaire[83] also reminds us that Fourier had another, harsher, side to his character, something which was to prove useful in his defence of the Analytical Theory of Heat.

Nevertheless, in spite of brilliant personal and intellectual qualities which made Fourier at once welcome and at ease in the best Parisian circles of the Restoration, not to speak of that citadel of Gallic wit and culture the Académie Française, it would be unrealistic to attempt to strike any sort of historical balance between Fourier the man and Fourier the savant. As a savant he achieved an international position, and increasingly dominated the theoretical physical scene in Paris—itself still the world centre of the subject—from his election in 1822 to the position of permanent secretary of the Académie on the mathematical side till his death in 1830. As a man he never achieved anything beyond local fame or notoriety: no doubt the president of the revolutionary committee of Auxerre in 1794 was both admired and feared by many of his fellow citizens, but they all resided in Auxerre or its immediate vicinity. Admittedly Fourier the revolutionary appeared for a brief moment on the national scene, albeit ignominiously, when named in Barère's decree to the Convention of Brumaire 1793. As for the Orléans affair which had prompted Barère's decree with its near fatal consequences for Fourier, apart from Fourier and his immediate friends and enemies in Auxerre and the all-seeing eye of the Committee of General Security it must have passed unnoticed amid the great political storms of 1793 and 1794 and would be completely forgotten today if it were not for the fortunate survival of many of the documents of the case and Fourier's eminence as a mathematician and a physicist. Certainly we are entitled to speculate that Fourier *might* have played a much more important part in the Revolution if he had been elected to the National Convention. There his charm and persuasive oratory could just conceivably have succeeded, for example, in turning the tide in favour of Louis where the turgid rhetoric of Condorcet was of no avail. But in September 1792 Fourier was barely twenty-three, was still almost too young to enter local politics let alone the national arena, and would in any case have stood no chance of election in Yonne against candidates like Michel Lepelettier or Nicolas Maure. In Egypt, again, his position as permanent secretary of the Cairo Institute and his many administrative functions made him the most important civilian member of the expedition. But little was heard of anyone but Bonaparte before the latter's return to France, and thereafter the expedition passed into virtual oblivion forgotten by almost everyone apart from the friends and relatives of its unfortunate members. Finally, as Prefect of Isère Fourier was admired, respected, and perhaps even loved by the great majority of the citizens of the department. But in that position he was no more than one among eighty-three Napoleonic prefects—though he may well have been the most able and successful as he certainly is almost the only one of them remembered today with the possible exception of Chabrol—and during his many years in Grenoble he was known in Paris only to a select band of savants and administrators, his path to any further advancement blocked by Napoleon's unswerving secret aversion dating from Fourier's too open support for Kléber in Egypt. As a politician, an administrator, a prefect of the Napoleonic regime, Fourier can therefore merit no more than a footnote in the history of the period, whereas both as a physicist and a mathematician he was undoubtedly one of the major figures of the nineteenth century and beyond.

Nevertheless the fact that according to normal historical standards Fourier the man hardly measures up to Fourier the savant does not mean that the former should be ignored in comparison with the latter. At the very least Fourier provides an intensely interesting example of one of a rather small number of eminent savants—the majority, as it happens, and no doubt not purely by chance, fellow Frenchmen, who, like Fourier, lived through the storms of the Revolution—who have also played a more or less distinguished part in the general life of their times. It is not unreasonable, then, to ask to what extent, if at all, Fourier's rich and varied experience of life conditioned his achievements as a savant beyond his obvious and unavoidable dependence on his local, national, and European environments for the satisfaction of those early physical, spiritual, emotional, and educational needs which necessarily underpinned all his later achievements in science.

Fourier appears to have been the only one of a family of fifteen brothers and sisters who distinguished himself in any way. The conclusion is irresistible that in Fourier's case it was a favourable combination of genes rather than any environmental factors which determined his initial intellectual advantage, and no doubt this was due in the first place to a memory which by all accounts would seem to have been of quite extraordinary accuracy and tenacity. This may have been partly hereditary, for it will be remembered that this gift had emerged at least once before in the Fourier family in the person of the Blessed Pierre Fourier who is said to have had the *summa* of St. Thomas Aquinas by heart. By itself such a phenomenal memory was, of course, no guarantee of anything beyond a parrot-like ability to repeat without effort whatever he heard or read. But as Fourier himself said in his *éloge* of Laplace: 'memory is a precious gift which is not genius but serves it for acquiring and retaining'. Allied in Fourier's case to a quick understanding and wide interests it enabled him to excel in all his studies until his encounter with mathematics around the age of thirteen marked the first turning point in his career. Without this youthful passion for mathematics Fourier would doubtless still have distinguished himself in some way or other, but it would not have been as a theoretical physicist. The encouragement and stimulation of Bonard, by all accounts an outstanding mathematics teacher, may have been, indeed probably was, a decisive factor here, and it is perhaps significant that the year 1781 in which Fourier attained the age of thirteen was also the year in which Bonard began to teach mathematics in Auxerre.

The advent of the Revolution then marked the next turning point in Fourier's career. Otherwise he would certainly have taken his vows and spent the rest of his life in the Congregation of St. Maur. Perhaps he would still have acquired some fame as a mathematician, have become a correspondent of the Académie des Sciences, or even a member if he could have managed to have himself transferred to the Congregation's Paris house at St-Germain-des-Près. Or he might have found an outlet for his administrative talents as Father Superior of some great abbey such as St. Benoit-sur-Loire. As it was, the Revolution put an abrupt end to his ecclesiastical career and opened up entirely new vistas outside his continuing work in teaching as assistant to his old master Bonard. His conversion to Republicanism and entry into local politics via the popular society of Auxerre, his membership of the local revolutionary committee and his various missions to the surrounding regions, above all that to Loiret, then sucked him into the maelstrom of local revolutionary politics and led directly to his two imprisonments from both of which he evidently suffered deeply, especially the first imprisonment in Auxerre when he seems to have been fortunate to escape with his life.

But the Revolution not only left its mark on Fourier by the suffering it imposed on him, not to speak of the resulting large increase in his experience of life and dealings with his fellows, it was also directly responsible for opening up a career for him in mathematics at a level he could never have hoped for as a teacher in the Congregation of St. Maur or at the École Royale Militaire in Auxerre. For his attendance at the École Normale—that short-lived child of the Revolution—brought him to the attention of Laplace, Lagrange, and Monge which in turn led to a position at the École Polytechnique where his subsequent appointment to Lagrange's chair of analysis and rational dynamics then opened up the most promising of prospects for a professional career in mathematics. Whether Fourier would have achieved his present fame if he had continued uninterruptedly at the École Polytechnique must remain a matter of speculation, and conceivably he might then never have become interested in the analytical theory of heat. Certainly it is a curious fact that during a stay of almost three years at the École Polytechnique between September 1795 and May 1798 he only contributed a single paper to the 'cahiers' of the school. This *could* have been an indication that teaching and administration were taking up an undue proportion of his time and energies at an age—around thirty—when according to Hardy's (doubtful) hypothesis he should already have passed the peak of his inventiveness as a mathematician. In any case his experience in Egypt was certainly very different from any he could have had in Paris, and his important administrative and other responsibilities in that country may have made it difficult for him to settle down to a sheltered academic life on his return to France, and thus have led him to accept the position of Prefect at Grenoble in the hope that, in spite of its obvious disadvantages, it would be a stepping stone to some other larger and more congenial position in Paris.

Fourier took up his position as Prefect of Isère early in 1802. A year later in the middle of 1803 he must have been thoroughly at home in Grenoble. No doubt he found the administrative problems with which he was faced there comparatively simple compared with those to which he had improvised solutions amid the continuing chaos and alarms of the Egyptian scene. The French prefect was—and to some extent still is—an absolute monarch in his own domain for whom all material aids and comforts of life are supplied without question. As prefect Fourier could always command the best servants from domestic helpers to the members of his own special 'cabinet'. For intellectual stimulation he had the pick of the most intelligent and entertaining citizens of Grenoble, men like Champollion-Figeac, the municipal librarian, and his more brilliant younger brother who was later to unlock the key to the Egyptian hieroglyphics. And from time to time if life in Grenoble itself palled somewhat, there were always visits to the different corners of his kingdom and beyond. All in all however much Fourier may have grumbled from time to time about his 'exile' in Isère, life in Grenoble, especially in the early years before he had given up all hope of an eventual move to a larger post in Paris, had its very decided

advantages. There must have been evenings then, when there were no callers and no visits to be paid, after dinner when his *aides* had been dismissed, when he drew up his chair before the fire and allowed his mind to turn back to his ambition of earlier years to become a great mathematician in the manner of 'Newton and Pascal'.[84] This ambition had been submerged by other and more pressing commitments, increasingly by the Revolution from 1789 onwards, totally from 1793 to 1795 and again to some extent by the Egyptian campaign from 1798 to 1801—though even in Egypt the ambition had never been forgotten and he had somehow found both the time and the energy to take up his researches into the theory of equations again, for according to Navier one of the mathematical papers on that topic found among Fourier's papers after his death was written in Egyptian ink on Egyptian paper. When he finally returned to France in the autumn of 1801 it was with the express intention of devoting himself again to mathematics once he had cleared away some work on the Egyptian zodiacs. It is not then surprising to have clear documentary evidence[85] that Fourier had become active again in pure mathematics by the middle of 1804. What calls for an explanation is not this quite natural renewal of his former work in pure mathematics under the favourable conditions in which he found himself in Grenoble once he had become firmly established as Prefect of Isère, but the fact that he became interested in the problem of heat conduction. Granted that his reputation as a physicist is based entirely on his Analytical Theory of Heat, and that this is largely true also of his reputation as a mathematician which would have been immeasurably less if based solely on his work in equations, it is evident that his encounter with the analytical theory of heat was the central event in his career as a savant.

A considerable prior interest in theoretical physics as opposed to pure mathematics is of course evident from the paper of 1798. But it is an interest in the subject from the formal, mathematical point of view, and under the obvious influence and inspiration of the Lagrange of the *Mécanique Analytique*. At this point a curious fact about Fourier comes to mind. When we look at all the most outstanding French theoretical physicists born in the eighteenth century—Clairaut, d'Alembert, Lagrange, Laplace, Fourier, Ampère, Poisson, and Fresnel—then we find that Fourier and Fresnel were the only ones who made no contribution to Analytical Dynamics, a subject which had been largely monopolized by the French School from the time of Clairaut onwards. That Fourier was familiar with the basic Newtonian system is clear from his lectures, and he must have been familiar with Lagrange's *Mécanique Analytique* and some at least of Laplace's voluminous writings in the subject. Why then did he at no stage show any sign of contributing himself? Two possible explanations suggest themselves: in the first place, around 1803 so much work had already been done in the subject that it could have appeared somewhat *viel jeu* to a discerning onlooker such as Fourier, though Poisson[86] was soon to show that there was still room for contributions sufficiently original to renew Lagrange's long lapsed interest in mechanics and lead to his final burst of creativity as a mathematical physicist. The other and possibly more likely reason was a natural antipathy to Laplace. This is perhaps already evident from Fourier's first assessment of him at the École Normale Year II as 'among the first of European savants'[87] as opposed to Lagrange who was quite definitely 'the first', or of his comment that Laplace's method of lecturing was undistinguished, or of the malicious story of Laplace's 'election' to the École Normale. Fourier's apparent lack of enthusiasm for analytical dynamics could then have been arisen in part from a disinclination to enter a field which around 1803 was entirely dominated by Laplace. It is interesting to note here *en passant* that although Fourier was always respectful to Laplace, and was not above making a graceful compliment to him on occasion,[88] he was never in any way deferential to him, as is evident, for example, in the whole tone of the letter of 1808/9 in which he quite firmly put Laplace in his place over the question of trigonometrical series.[89]

If plausible reasons can be found for explaining a lack of any contribution to, or apparent interest in, analytical dynamics on the part of Fourier, what of the other branches of theoretical physics apart from heat in which important developments took place in the first quarter of the nineteenth century, namely, in electricity and magnetism, and in the theory of light? No very good reason can be given in the case of electricity and magnetism. For against the argument that the great burst of creativity in electromagnetism led by Ampère had to await Oersted's discovery of 1820, we have the fact of Coulomb's brilliant work in both electricity and magnetism which can scarcely fail to have been known to Fourier,[90] and which influenced Poisson's fundamental contribution of 1806. In the case of light a much stronger case can be made out for Fourier's failure to participate, namely it would have been necessary for him either to have been able both to read and to understand the original papers of Young, a formidable undertaking of which he was in any case almost certainly linguistically incable, or he would have had to rediscover the basic phenomena for himself like Fresnel, but before Fresnel, and without the invaluable assistance of Arago or the stimulation of the discoveries of Malus, once again a somewhat improbable proceeding. As for heat, for some years prior to 1804 there had been considerable experimental activity in thermal phenomena, both on the question of propagation of heat in solid bodies, and in thermal radiation. It seems, however, that Fourier knew nothing of this work before he learnt of it through Biot's paper, which in turn directed his attention to study the propagation of heat in a thin bar, the real beginning of his Analytical Theory of Heat.[91] But Biot's work was not responsible for arousing Fourier's initial interest in a theoretical treatment of thermal phenomena in the first place. This interest had already shown itself in his earlier researches in the subject into the communication of heat between discrete bodies. Without this prior interest it seems unlikely that Biot's somewhat pedestrian paper of 1804 would have aroused anything more than a transient response in Fourier, whereas in the light of his earlier researches he was in a position to respond critically to the incomplete, but very suggestive, sketch for a theoretical treatment of the thin bar problem in Biot's paper, incorporate it in his draft paper of 1805, and then transform it into one of the cornerstones of the memoir of 1807. It is evident, therefore, that the first decisive step in Fourier's Analytical Theory of Heat was his original treatment of the communication of heat between discrete bodies. His reproduction of the whole of this topic in the 1807 memoir, the Prize Essay, and the Analytical Theory of Heat, is a good indication that Fourier himself was of the same opinion. As for the *reason* for Fourier being drawn to this particular topic in theoretical physics soon after his arrival at Grenoble, this must remain a matter of speculation though it is tempting to suppose that it was simply due to the almost pathological personal susceptibility to cold which he experienced on his return from Egypt,[92] and which ensured that the question of heat, its loss by propagation in solids and radiation in space, the problem of conserving it—on which Fourier himself advanced interesting suggestions in his Analytical Theory[93] —can never have been out of his mind for long, at least during the winter months.

If this were the only point at which Fourier the man impinged on Fourier the mathematician and physicist, the search for some sort of meaningful rapport between the human and the scientific sides of his life would have proved abortive. But when we take into account the controversy[94] arising out of the 1807 memoir we find other more profound and interesting ways in which Fourier's experience of life contributed to his achievement in science. The more closely this controversy is looked at the more apparent is the extreme gravity of Fourier's position. Laplace and Lagrange on whose good opinion and support he must have counted, and whose influence in the commission was dominant, had both turned against him. Nor was it simply a matter of a number of rather narrow questions to which precise yes or no answers could eventually be found. The two major criticisms of Fourier's work were both of a somewhat nebulous and intangible nature. His derivation of the basic equation of motion was supposedly lacking in 'rigour', this could be supplied, but even if Laplace could be persuaded to accept Fourier's derivation he still *preferred* his own. The question of the use of trigonometrical expansions was much more subtle and difficult and in spite of all Fourier's persuasive arguments Lagrange could never bring himself to accept the validity of Fourier's procedures. The whole work was therefore at stake. Laplace and Lagrange remained openly opposed to it and Biot lost no opportunity of sniping at it from the side lines. The danger of an absolutely damning report was therefore very great. It was at this point that a long experience of pleading difficult cases came to Fourier's aid. To ward off the attacks of Biot and Laplace, to neutralize if not remove the misgivings of Lagrange, required the protracted exercise of all Fourier's considerable powers of persuasion both literary and mathematical. It was here that Fourier the man intervened most decisively in the career of Fourier the savant. The persuasive eloquence which had pleaded the case of the innocent before the popular tribunes in Auxerre during the Revolution, or which had pleaded for his own life and liberty in the letters from prison to the *conventionels* Bergoeing and Villetard during the Prairial days of 1795, was now pressed into service to defend a theory which was fighting for its life against the conspiracy of Biot, Laplace, and Poisson. The letters[95] to Lagrange, Laplace, and other unnamed correspondents provide the only extant evidence for this defence, but no doubt Fourier found the opportunity to defend his memoir even more persuasively in person on the occasion of his extended visit to Paris in 1809/10 to oversee the printing of his Introduction to the *Description of Egypt*. It would be tempting to argue with hindsight that truth is great and must prevail, that Fourier's theory was in all essential respects correct, and would, therefore, inevitably have triumphed regardless of whether or not he had defended it. But if he had not reacted vigorously, and on occasion ruthlessly, against the Biot–Laplace conspiracy, if he had not had the daring and effrontery to criticize Laplace openly in a letter[96] to some unknown, but obviously influential person—an action as dangerous scientifically in 1809, when Laplace was very much the 'dictator' of the physical sciences in France, as Fourier's action in criticizing the *conventionel* Laplanche had been dangerous politically in 1793—then there is every reason to believe that Fourier's paper would have been forgotten, the subject of the propagation of heat would not have been set as a Prize Essay, or that if it had Fourier would have been too discouraged by the reception of his earlier memoir to submit another. In that case no doubt all the results in the analytical theory of heat would ultimately have been discovered independently and the theory of the conduction of heat in solids would be little different today from what it actually is. Nevertheless the loss to mathematics and theoretical physics in the nineteenth century through the non-appearance of Fourier's work would have been immense, for the chances of another single work combining at one and the same time so much mathematical originality with so many new methods and results in applied mathematics and theoretical physics would have been vanishingly small. Certainly Poisson's[97] ponderous work on the subject would have supplied no sort of acceptable alternative to Fourier's Analytical Theory of Heat. What would have been so sorely missed would have been the enormous impact on both mathematics and theoretical physics of Fourier's treatise, as a result of its compelling elegance and clarity, and its simultaneous presentation of so many original results. Science and mathematics would have had to make do instead with a patchwork of independent results as opposed to a single, connected masterpiece.

Compared with some of his contemporaries, especially Lagrange, Laplace, and Cauchy, Fourier's collected works take up a rather modest space on the shelves which carry the forgotten writings on which the triumphs of modern theoretical physics are largely based, and in Fourier's case his collected works were almost entirely made up of a single work, the Analytical Theory of Heat, and deductions therefrom. Few works, however, have contained so many original results or have had so great an influence in both pure and applied mathematics and in theoretical physics. Fewer still have represented such a rounded, human achievement. To the creation, composition, exposition, defence, and publication of this work he devoted all his gifts of intellectual energy, creativity, persistence, clarity, eloquence, and persuasion as a mathematician, a physicist, a writer and an advocate, so that the Analytical Theory of Heat must be regarded not only as a memorial to Fourier the mathematician and physicist but also to Fourier the man. Perhaps at this point Fourier still has something to say to the present age when all his purely mathematical and physical achievements have long since been inextricably interwoven into the fabric of modern mathematics and science. To the romantic argument that great achievements in art, literature, and science are reserved for those who sacrifice everything to their chosen subject Fourier, as a true son of the French Enlightenment, provides the example of one who succeeded in combining achievements of the highest order in mathematics and science with a profound interest in life, literature, and art not to speak of a successful career in administration. At a time when the experimental way of the seventeenth century is increasingly under attack for its contributions to certain of the ills of modern society, Fourier reminds us of the Baconian message that the true end of science is not the advancement of knowledge—important though that is—but the increase in the real happiness and well-being of mankind, and that if we have to choose—as now seems likely—between depth of knowledge and quality of living we shall have to choose the latter rather than the former. Also that an essential factor in this quality of living is supplied by the old classical notion of that delicate balance between conflicting subjects, interests, and occupations which makes up true culture, that if the arts man without some knowledge of science is an 'ignoramus', the scientist without a living interest in literature and art is a 'barbarian',[98] and that the proper function of education as in Fourier's own École Royale Militaire in Auxerre is to prevent the production of narrow specialists while still fostering a love of individual excellence in all its varied forms.

Notes

1. Historical Précis, fol. 162.
2. 1807 memoir, fol. 3.
3. See above, chapter 10, p. 206.
4. See above, section 10.2.
5. For example,

> These theories [those on terrestrial heat] will expand greatly in the future, and nothing will contribute more to their perfection than numerous sets of precise experiments: for mathematical analysis (if we may be permitted to reproduce* this reflection) can deduce from general and simple phenomena the expression of the laws of nature: but the application of the laws to *very* intricate effects requires a long sequence of exact observations.

Oeuvres, **2**, p. 125, *Preliminary Discourse to the Analytical Theory of Heat.

6. See above, chapter 10, pp. 202–5.
7. Ibid., pp. 204–5.
8. See, for example, his reference to Fourier's work on terrestrial heat in his 'On the secular cooling of the earth', *Trans. Roy. Soc. Ed.*, **23** (1864), 157–69.
9. See above, chapter 8, pp. 164–5.
10. Ibid., pp. 165–6.
11. See Appendix, pp. 308–9.
12. See Appendix, p. 308.
13. See above, chapter 9, pp. 183–5.
14. See above, chapter 8, pp. 166–7, chapter 9, pp. 185–6.
15. Appendix, pp. 312.
16. Loc. cit., art. 19.
17. See above, chapter 9, pp. 186–7.
18. See above, chapter 8, p. 182: 1807 memoir, arts. 17, 18.
19. See, for example, Rosenberger, F., *Die Geschichte der Physik*, vol. 3, pp. 110–11.
20. Biot (1), p. 321.
21. 1807 memoir, art. 16.
22. See above, chapter 8, p. 170.
23. Loc. cit., fol. 127v.
24. See above, chapter 8, p. 170.
25. See especially Bose (2), Grattan-Guinness (1), (2), Jourdain (1), (2), Langer, Van Vleck.
26. For this controversy see Bose (2), Langer, Mach, pp. 78–114, Grattan-Guinness (3), chapter 10, Ravetz (2).
27. See, for example, Monna, A. F., 'The Concept of Function in the nineteenth and twentieth centuries'. *Archive for History of Exact Sciences*, **9** (1972), 57–84.

28. Op cit., fol. 116.
29. See below, Letter XXI, p. 320.
30. Jourdain, p. 250; Van Vleck, pp. 116–17.
31. Van Vleck, pp. 118–19.
32. Ibid., pp. 120–1.
33. Ibid., p. 120.
34. For evidence of the introduction of these methods into British mathematics see Herivel (2).
35. See above, chapter 9.
36. See above, chapter 5, pp. 100–3, and chapter 7, pp. 153–8.
37. *Principia*, Book I, *Scholum* to Laws of Motion.
38. As opposed to his treatment of the problem in unpublished MSS. See my *Background to Newton's Principia* (Oxford, 1965), chapter 5.
39. As opposed to the very evident mathematical manipulation and transformation of these equations which is always given, in part at least, in the finished work.
40. Especially his *Études Galiléennes.*
41. Greene, pp. 7–8.
42. Quoted in Jourdain (2), p. 245.
43. See above, chapter 10, pp. 197–202.
44. Especially the paper referred to in n. 8 above.
45. See above, chapter 10, pp. 203–4.
46. Analytical Theory of Heat, p. xvii.
47. Ibid., pp. xvii–xviii.
48. Ibid., p. xxii.
49. Ibid., p. xvii.
50. Ibid., p. xxviii.
51. Ibid., p. xxiv.
52. Ibid., p. xxv.
53. Ibid., pp. xxv–xxvi.
54. Ibid., p. xxiii.
55. Ibid., p. xxiii.
56. Ibid., p. xxii.
57. Quoted by Jourdain (1), p. 249.
58. Analytical Theory of Heat, p. xxiv.
59. Ibid., p. xv.
60. Ibid., p. xxi.
61. Ibid., p. xxviii.
62. Ibid., p. xxi.
63. Quoted—slightly incorrectly—by Fourier at p. xvi.
64. Analytical Theory of Heat, p. xvi.
65. Ibid., p. xxviii.
66. Thus Hermite (*Oeuvres*, **4**, p. 287) states that: 'For Laplace and Poisson pure analysis was not the object but the instrument, the applications to physical phenomena were their essential objectives.'
67. Thus Maupertius in his *Discours sur la figure des astres* states:

> It is a justice which one must render to Newton; he never regarded attraction as an explanation of the weight of one body towards another: he often warned that he used the term to designate a fact not a cause; that he only used it to avoid explanations and systems: that it could even be that this tendency was produced by a subtle matter from bodies and was the effect of an actual impulse; but that, whatever was the case, it was always a prime fact from which one could proceed to explain facts depending on it.

Maupertius, *Oeuvres*, 1, p. 92. Or d'Alembert, in his *Discours Préliminaire* to the *Encyclopédie* who points out that in certain regions of physics where it has so far proved impossible to apply mathematical calculations the only resource is to

> collect as many facts as possible, to dispose them in the most natural order, to connect them to a certain number of principle facts from which the others can be drawn as consequences.

68. A particularly striking account of Lavoisier's attitude is given in the *Discours Préliminaire* to his *Traité Élementaire de la Chimie* (*Oeuvres*, 1 (1864), pp. 1 ff.
69. For an account of *idéologue* thought see Picavet, Van Duzer.
70. Especially his *Essai sur l'origine des connaissances humaines*. For a recent account of Condillac's philosophy see the work by Knight.
71. Thus d'Alembert, *Discours Préliminaire* to the *Encyclopédie*

> The universe, if we may be permitted to say so, would only be a single fact and a great truth for whoever wished to embrace it from a single point of view:

or Laplace

> All phenomena, even those which by their smallness seem to be independent of the great laws of nature, are in fact the consequences of these laws every bit as necessary as the revolutions of the sun. In our ignorance of the links which connect them to the whole system of the universe they have been made to depend on final causes or on chance, depending on whether they occur regularly or without apparent order, but these imaginary causes have been successively pushed back with the bounds of our knowledge, and they disappear entirely before the wise philosophy which sees in them the expression of our ignorance of the true causes.

Essai Philosophique sur les Probabilités (3rd ed., Paris, 1816), p. 2.

72. Thus for Lavoisier truth was only to be found 'in the natural linkage of experiments and observations' (op. cit., p. 4).
73. Op cit., fol. 158.
74. Analytical Theory of Heat, p. xvi.
75. See below p. 234.
76. See Gouhier, vol. 3, p. 235.
77. Comte, vol. 1, p. 17.
78. Ibid., vol. 2, p. 435.
79. Ibid., vol. 2, p. 648.
80. Some consideration has been given to this question as regards the physical sciences in Herivel (1), Fox (especially pp. 262 ff.) and Boughey (unpublished thesis). For the biological sciences see the interesting account of attitudes in Cahn, chapter 26.
81. See Herivel (2).
82. See above, chapter 6, p. 135.
83. See above, chapter 4, p. 75.
84. See below, Letter II, Appendix, p. 251.
85. See Grattan-Guinness (3), p. 82, n. 6.
86. See Biot, *Mélanges*, vol. 3, p. 122, n. 1.
87. See below, Letter VI, Appendix, p. 259.
88. For example, in a letter of around 1806 found in BN MS. 22501, fol. 71.
89. See below, Letter XX, Appendix, p. 316.
90. On the other hand we must remember how Fourier excused himself for lack of references to earlier works on trigonometrical expansion on the grounds that no mathematical works were available in Grenoble. See Letter XXI, Appendix, p. 320.

91. See above, chapter 8, pp. 162–6.
92. See above, chapter 5, p. 99.
93. Op. cit., chapter 1, sect. 6.
94. See above, chapter 5, pp. 100–103, chapter 7, pp. 153–8.
95. See below, Letters XVII–XXI, Appendix, pp. 302–321.
96. See below, Letter XVII, Appendix, p. 303.
97. Poisson (5).
98. Cousin, p. 39.

APPENDIX: LETTERS

I

Fourier to Bonard, May 1788

This 22 May 1788.

Sir,

On occasion others have graciously forgiven me too long a silence; I hope for the same indulgence from you. This accursed habit follows me everywhere, call it what you will; the fact remains that I like and infinitely esteem people, and yet do not write to them. However, I only wrong myself, it is one pleasure the less and you know that I have said goodbye to pleasures for the moment.

I allow myself few details on my present situation: *sunt bona mixta malis.* I am present at studies, classes, recreations, and arithmetic lessons; we shall soon be at fractions; all these petty concerns and a thousand others render me neither less content nor less happy. I did not want to devote myself to pleasures, but rather to study and to religion. Esteem and friendship make up for everything. Many people here are predisposed in my favour, but I honestly fear that I may not live up to the notion they have of my talents. I have made so exclusive a study of mathematics and science that in literature I am only left with a taste for the subject and very little expertise in it.

I have quite lost sight of what I wrote in algebra,[1] I really must busy myself with it one day. I wait for news. I should be enchanted to know the opinion of the mathematicians! But it would be pointless to hope for anything else, [though] I have no doubt of your interest in the matter.[2]

I pay with interest to Morphée all the nights I stole from him at Auxerre: there is no time left for living when one sleeps eight hours [a night], and my nights are not those of Descartes.[3] My health[4] is as good as it can be: rest and a regular life no doubt contribute to its improvement. In short, up to the moment I am far from repenting a step taken against the advice of many persons.

I have examined your solution of this little question in analysis, it is very elegant: the result agrees with mine, and hardly with that of M. de Guistiniani;[5] he must be consoled for this mischievously; I shall write to him perhaps one of these days; I should like to know how he is getting on in his new position, and what is your opinion on this subject and that of Dom Laporte[6] and his [Guistiniani's] pupils. I still do not know if I shall be able to send you on this present occasion a certain memoir that I cannot decently keep any longer, for it is certainly yours. I have not forgotten it.

Here is a little problem of a rather singular nature: it occurred to me in connection with certain propositions in Euclid we discussed on several occasions. Arrange 17 lines in the same plane so that they give 101 points of intersection.[7] It is to be assumed that the lines extend to infinity, and that no point of intersection belongs to more than two lines. The problem must be reduced purely to analysis so that given m and n one can arrive at the necessary equations.

Your memoir on a curve with double curvature should have been returned to you. The author of this memoir is to a good mathematician as are alchemists to competent chemists.

Dom Vaudret[8] and I recommend our sundial to you; if he who made the style has acquitted himself badly, I charge you to revenge me for his clumsiness.

I am sure that as soon as M. de Montuclas[9] [*sic*] has replied to you, you will not fail to inform me.

You could also send me some mathematical, physical and astronomical news etc.; M. de Guemadeuc[10] is in a position to instruct you. I would like to know if the Marquis de Condorcet[11] has had published what he is said to have written on modern calculus; if it is true that M. de la Grange[12] and other *academiciens* employ eight months of the year in visiting the Écoles Militaires; I cannot persuade myself to believe it.

As to political news: those that fight each other destroy each other.

I have surrendered to Du Plessis[13] my subscription to the *Journal de Genève*.[14] The world and I are going to grow several years older without knowing each other.

I end a letter which is already too long, you could revenge yourself by the length of yours; there would also be a way of correcting my negligence, namely by setting me an example of the opposite quality. I recommend you to try this method, you will oblige him who with sentiments of esteem and attachment has the honour to be

Your very humble and obedient servant,
Fourier

To M. [Bonard], M. Fourier, at the royal abbey of St. Benoit-sur-Loire.

Notes

1. Navier,* in his introduction to the posthumous edition (1831) of Fourier's *Analyse des équations déterminés*, refers to an early work by Fourier entitled *Recherches sur l'algèbre*. Navier had seen an incomplete copy of fourteen pages of this work certified by Fourier's close friend Roux to have been in the hand of Bonard who told Roux that it had been composed by Fourier when scarcely eighteen years old (i.e. early in 1786). Bonard also said that a more careful copy of this paper was sent to Paris in 1787. This is presumably the work to which Fourier refers here.

   * Navier, L. M. H. (1785–1836). Mathematician and engineer. He entered the École Polytechnique in 1802 and passed on to the École des Ponts et Chaussées becoming an engineer in the department of the Seine in 1807. He entered the Académie des Sciences in 1824 and the same year was put in charge of a suspension bridge over the Seine. Navier had the unfortunate experience of seeing this bridge collapse before his eyes, but his reputation was very great and was little affected. He was called to one of the chairs of analysis and mechanics at the École Polytechnique in 1831. He was the author of a number of important papers on elasticity and on the movement of fluids and is remembered by the so-called Navier–Stokes equations for the motion of viscous fluids. He was a close friend of Fourier who entrusted him with the care of his mathematical papers after his death, especially the manuscript of his work on algebraic equations (*Bio. Gen.*; *Gde. Encycl.*).
2. Reading between the lines it would seem that Fourier had originally some hope that the brilliance of his paper would not only impress the 'mathematicians' but would also lead to 'something else' perhaps a teaching position in mathematics. In fact we know that on leaving St. Benoit he returned to Auxerre to assist Bonard in the École Royale Militaire.
3. Meaning that Fourier's nights were not spent *usefully* like those of Descartes in dreams which suggested the strategy of his philosophical researches.
4. According to a *curriculum vitae* of Fourier (Fourier Dossier AN) he suffered in 1783–4 from a serious illness possibly brought on by excessive application to his studies including those carried on surreptitiously by candle-light in the suffocating atmosphere of the 'cupboard'.
5. No trace of a de Guistiniani has survived in the local records. Possibly it was a pseudonym.
6. Charles Marie Laporte. Born at Ambournay around 1755. He obtained a position in the École Royale Militaire where he was for a number of years deputy principal under the principal, Rosman.* In 1790 he was one of a list of teachers proposed to the municipality by Dom Rosman. He was dismissed from the college in April 1793 with the other so-called professor–priests on the demand of the local Popular (Jacobin) Society. On leaving the college he became *curé-doyen* of Touchy. We do not know when he resigned this living but on returning to Auxerre he offered his services to the college following its reorganization by Dom Rosman in 1794–5. He was evidently not accepted, and in November 1795 we find him president of the council of the commune of Auxerre. He was still in this position when he was admitted as professor of legislation to the École Centrale in 1796. When a secondary school was to be set up to take the place of the École Centrale the municipality at first proposed Laporte as director. Ultimately, however, a Monsieur Choin was chosen for that position and Laporte did not enter the school until 1806 when he succeeded Choin. He was accompanied by his close friend Ducastel who had refused two years earlier to enter the school in the absence of Laporte.

   Laporte continued as director till 1825 and during the whole of this time there were excellent relations between the school and the town. His administration had a strong religious tincture, something which suited the temper of the majority of the townsfolk who (like Fourier) had long abandoned the revolutionary fervour of 1789–94. However, judging by the following extract from a letter written in 1821 not all the pupils found the instruction or tone of the school to their liking:

> M. Laporte made me stay in again yesterday during the walk. He has recently done certain things which would make one think him a trifle mad. He confiscated a very instructive geography book which spoke of all the departments of France and their origin, of their productions, of the great men born in the different towns, of the various wars, of the remarkable things which one finds there, because among these numerous citations there was one of a gentleman from a certain part who thus commenced his testament: 'I leave my soul to the Devil, my immodesty to the Capucins and my wine cellar to the monks . . .' He preached on this for half an hour and ordered that the person who had the book should have several impositions and should not go for a walk, and on the score of it treated us as impious libertines and atheists. He so tormented a young man of Autun that he was forced to write to his parents to come and fetch him and he left at 11.00 in the evening. As for myself, I do not bother myself much with what he says, I do my duty in class the best I can.

And he continues later,

> if you knew how arid and boring are the things we have to do you could not imagine it. When I have worked an hour or an hour and a half I assure you that I have had enough; we only work on 'letters' which have no more sense for us than Hebrew. M. Roux tells us that it is only the beginnings which are difficult and that the rest is amusing. I hope so.

Laporte lived on for four years after retiring from his position at the school. He died in 1829 with a great reputation for saintliness and generosity, mourned by all sections of the community, and two busts were erected to his memory, one in the cathedral and one in the cemetery (*Arch. Yon. Cestre* (2)).

* See below Letter XII, n. 5.

7. The data given by Fourier leads to an impossible 35 pairs of parallel lines. If 101 were an error for 131 the answer would be 5 pairs of parallel lines and 7 other lines.
8. On the closure of St. Benoit-sur-Loire at the time of the Revolution its archives were placed in the departmental archives of Loiret in Orléans. These latter were largely destroyed by bombing in 1940. No record therefore remains of Dom Vaudret or other humble inmates of the abbey.
9. Montucla, J. E. (1725–99). Historian of mathematics. Educated by the Jesuits at Lyons he came to Paris where he made the acquaintance of d'Alembert, Diderot, and their circle, and obtained a position in the *Gazette de Paris*. He was appointed secretary to the *Intendant* at Grenoble in 1761, and was a member of the astronomical expedition to Cayenne in 1764. Soon after his return to France he was appointed head clerk of the royal buildings and royal censor, positions which he later lost as a result of the Revolution. He retired to Versailles and devoted himself to the composition of his *Histoire des Mathématiques* of which the first two volumes were left incomplete at his death but were finished by Lalande (*Bio. Gen.*; *Gde. Encycl.*).
10. Armand Henri Baudoin de Guemadeuc. Born Colmar, 1734, died Paris 1814. Around 1785, with the aid of two other citizens, he constructed inside the church of the hospital of Tonnerre an astronomical sundial which is still standing. He was a member of the 'Lycée de l'Yonne' an historical and scientific society founded after the Revolution in Auxerre by the Prefect of Yonne, Rougier de la Bergerie. Fourier, who was a member of this society, was often in correspondence with Guemadeuc on astronomical topics (M. Richard, Auxerre, private communication).

11. Caritat, M. J. A. N., Marquis de Condorcet (1743–94). Educated by the Jesuits, and at the Collège Mazarin, he early attracted the attention of the foremost mathematicians of the day by his '*Essai sur le calcul intégral*' (1765). He was elected to the Académie des Sciences in 1769 and produced a number of important works on mathematics including a memoir on integral calculus (1772) said by Lagrange to have been 'filled with sublime and fruitful ideas which could have furnished material for several works'. About this time he became acquainted with Turgot and Voltaire and on the latter's advice and that of D'Alembert he began to train himself in the composition of academic *éloges*. This may have contributed to his election as permanent secretary to the Académie des Sciences instead of Bailly, but it also seriously interfered with his mathematical output and thereafter he produced no further works of importance in that subject.

    When Turgot became controller general of finances in 1774 he had Condorcet elected inspector general of moneys, a position which he retained after Turgot's disgrace—his own resignation being refused—and which he continued to fill up to 1791. When the Revolution broke out he became one of the foremost champions of the liberal cause. He was especially prominent for plans for the reform of French education later to be taken up by the '*Idéologues*'. After Varennes he became a Republican and thus lost most of his friends. Elected a member of the Convention by Aube, he mostly voted with the Girondists. With his friend Thomas Paine he pleaded in vain for the life of the King.

    When the Gironde fell Condorcet imprudently attacked the new constitution which had been hastily drawn up to replace the one for which he himself had largely been responsible. As a result he was denounced by Chabot, decreed arrested, and forced into hiding. In March 1794 he left Paris and after wandering for a few days in the suburbs was arrested as a suspect and died in prison (possibly by his own hand) on 29 March 1794.

    Like his uncle, for a time bishop of Auxerre, and from whom he had a small inheritance, Condorcet was no politician. His uncompromising directness of manner and inability to suffer illogical windbags in silence made him many enemies and few friends. His weak voice, lack of oratorical powers, and tendency to bore the Convention by the excessive height of his arguments was one of the tragedies of the Revolution. If his intellect had been matched by the eloquence and charm of a Fourier he might conceivably have saved the life of the King with incalculable consequences for the later history of the Revolution both in France and Europe.

    After a long absence from mathematics Condorcet took up his treatise on integral and differential calculus again including an entirely new treatment of infinitesimals. The printing of this new work began in 1786 but terminated at p. 17 and was never continued. No doubt it was this still-born work to which Fourier referred (*Bio. Gen.*; *Gde. Encycl.*; Robinet).
12. Lagrange, Joseph Louis (1736–1831). Born in Turin of parents of mainly French descent, being connected to Descartes on his father's side. He had at

first a great love of letters with no special interest in mathematics but by the age of seventeen he had already become a master, and a few years later had drawn to himself the attention of the foremost mathematicians of the day by his publications in the Academy of Turin. In 1764 he was awarded the grand prize of the Académie des Sciences for a memoir on the libration of the moon in which he made use of the principle of virtual velocities which was later to form the basis of his *Mécanique Analytique*. In 1766 he replaced Euler as director of the mathematical section in the Academy of Berlin remaining there until 1787 when he moved to Paris at the invitation of the French government and became a member of the Académie des Sciences of which he had been a foreign associate since 1772. After the publication of his masterpiece the *Mécanique Analytique* in 1788 he lost interest in mathematics for a time and devoted himself to other subjects, especially chemistry. In 1792 he became a member of the commission of weights and measures on which he continued to serve as president after the removal of Lavoisier, Borda, Laplace, Coulomb, and Delambre. He retired for a time during the Terror being saved from exile by the influence of Guyton de Morveau. On hearing of the execution of Lavoisier he remarked to Delambre: 'it has taken them but a moment to lop off this head but perhaps a hundred years will not suffice to produce the like again.' The foundation of the École Polytechnique re-aroused his interest in mathematics and led to the composition of his *Théorie des function analytiques* (1797) for the use of the pupils of that school. At the very end of his life he had a final burst of creative activity aroused through a paper by S. D. Poisson which led him to undertake a second edition of his *Mécanique Analytique* containing much new material. Lagrange was married twice, once in Berlin where he lost both his wife and their only child. In 1792 he married the young and beautiful daughter of the astronomer Lemmonier who rendered the last twenty years of his life ideally happy. Lagrange was a man of few words whose favourite expression was 'I do not know'. He always refused to allow his portrait to be drawn believing with Pascal that '*penser fait le grandeur de l'homme*' and that only the productions of the mind have a right to immortality. He was of a naturally delicate constitution and was extremely moderate in all things except work. Besides his work in analytical dynamics, Lagrange made important contributions to the theory of sound, to the theory of numbers, and to various branches of analysis especially the calculus of variations of which in company with Euler he was essentially the founder (*Bio. Gen.*; *Gde. Encycl.*; notice by Delambre (Lagrange, *Œuvres*, 1, pp. ix–li); Biot, J. B., (5), Vol. 3, pp. 117–24).

13. Possibly the same as the Duplessis who signed the 'patriotic address' of 15 October 1792 of the Society of Friends of the Republic in Auxerre in company with Bonard and other radicals, or the Huet-Duplessis listed as one of the professors of the college in Auxerre following the expulsion of the remaining 'teacher-priests' and its takeover by the radical party led by Balme and Fourier.

14. There were two 'Journal de Genève' appearing in 1788. One appeared only between August 1787 and January 1791 and was purely a depot of facts and information relating to the district of Geneva. The other, founded by Panckoucke under the title *Journal historique et politique* (45 Vol., 1772–83), and continued by Mallet du Pan the elder (16 Vol., 1784–7), was given the title *Journal historique et politique de Genève* (18 Vol., 1788–92). During its last period the printed cover bore the sole title *Journal de Genève*. Fourier is evidently referring to this latter journal. According to E. Hatin (*Bibliographie historique et critique de la presse périodique française* Paris, 1866, p. 73), 'The long duration of this sheet, founded by Panckoucke, which had the advantage of appearing three times a month, sufficiently proves the regard in which it was held by contemporaries: it can be consulted as a faithful resumée of all the gazettes and public papers of the period'. Fourier would therefore have been well informed of events in the external world at least up to the time of the surrender of his subscription.

II

Fourier to Bonard, March 1789

22 March 1789.

Sir,

I am going to take you away for a moment from possibly more agreeable and certainly more profitable occupations. I shall try not to be lengthy, but shall still be too long-winded. At a time when everything resounds with the news of the day, you nevertheless do not expect me to talk about it with you; it was only recently that I learnt that the States are to be held at Orléans,[1] and I would perhaps still not know about it if I did not know that the Father Prior is at present there to take part in the election. I would, however, be able to tell you that M. Favre is no longer the Knight of Hongry; he tells me in a letter dated 21 December that he is a postulant with the Bernadins,[2] a very strange metamorphosis. He wrote to me at the École Militaire. I replied to him from Saint-Benoit. I shall not talk to you of the accidents caused by the Loire;[3] they frightened many, and did harm to some, but to me neither one nor the other.

A misfortune which I feel much more is the lack of books. Is it not to be condemned to ignorance not to be able to read any other books but one's own? It is a privation not to be consoled by all philosophy. I have no books to read but a miserable copy of Montaigne lacking certain pages which I am reduced to guess at; I busy myself a little with Greek; you can well believe that it is for reading Euclid and Diophantus rather than Pindar and Demosthenes. My health is not too good. For the last five weeks I have constantly had a weak stomach and difficulty in sleeping. I sometimes think that I have bought very dearly[4] some rather fragile knowledge for which it will be difficult to find a market.

I have worked at these methods of elimination again; it is not difficult to see how defective are those commonly employed, but it is very difficult to replace them by better ones. You can certainly see that I would need to have the work of M. Bézout[5] on the same subject before me. Alone and without help one can meditate but one cannot make discoveries; often by flying the world one becomes better, but not wiser; the heart gains and the mind loses. Montaigne likes to preach *incuriosity*, he cannot make a proselyte of me. I have put in order everything contained in the memoir you have on numerical equations.[6] Everything is explained and demonstrated, but nothing is written. If I could be judge in my own case I would assure you again that these are the true methods, that the Italian ones are absurd and

opposed to all that is most certain in analysis, that they have held up the progress of algebra, that it is to them one must attribute all the disorder and imperfection that one is grieved to find in a science more than twenty centuries old; that it is impossible that a genuine mathematician should reject such powerful evidence. So, my dear sir, you can be certain that these truths only need to be known to be approved. But will they be? Admit that I have a right to doubt it. I begin to take M. Montuclas [*sic*] at his word when he tells us he has fallen out with learned analysis: I wait calmly for him to be reconciled with it.[7] To you, Sir, who have brought to the matter the concern of friendship, I can only offer my sincere but worthless gratitude. I was telling you that I have thought about the question of numerical equations; I have discovered a very inexact passage in the memoir in your possession; it concerns a theorem on the nature of the roots when certain of the coefficients are zero, its enunciation is defective. The application made of it in an example is no less incorrect. I beg you—and to do so is the first object of this letter after the pleasure of assuring you of my friendship—to make a little note on it, I shall tell you another time what the enunciation should be. This remark is of some consequence, one must not replace errors by errors.

Forgive me the trouble this letter has caused you, all the disorder and bitterness you will find in it. If you only knew the effect of a passion for the truth when it is constrained to be sterile, and all the treachery which ungrateful truth reserves for her devotees. But if it is hard to suffer her caprices, it is very pleasant to complain of them. And who would grudge me this pleasure? For me pleasures are so rare.

With all the esteem which is due to you and with the most sincere friendship, I am

Your very humble and very obedient servant,
Fourier

Yesterday was my 21st birthday, at that age Newton and Paschall [*sic*] had [already] acquired many claims to immortality.[8]

Notes

1. He is referring to the preliminary meeting of the three estates (clergy, nobility, bourgeoisie) of the Orléans district to draw up lists of grievances and elect delegates to the forthcoming meeting of the States General at Versailles. The meeting of the assembly of clergy took place in the church at the Cordeliers, Orléans, from 17 March to 2 April, 1789. From the minutes of this meeting (which have been preserved) it appears that the prior of the Abbey of St. Benoit, Dom Charpentier, played a leading part in the proceedings: he was a member of one of the bureaux for verifying the credentials of delegates, was one of twenty-six commissioners responsible for drawing up the '*Cahiers de doléances*' of this

assembly, and was elected scrutineer at the election of delegates from the assembly to the States General. He himself proclaimed the results (MS. 993, *Bib. Mun. d'Orléans*).

2. The name often given to the reformed order of Cistercians founded by St. Bernard of Clairvaux. Originally the order had been noted for its piety and the strictness of its rule, so that by implication the Knight of Hongry—who has left no other trace behind, though he was presumably one of the nobler kind of pupils at the École Militaire—was something of a gay dog before his metamorphosis.
3. A flooding of the Loire took place in January 1789 following a sudden thaw after a period of extreme cold. The bridge at Orléans was damaged, that of Jargeau was carried away, and four of the middle arches of the main bridge at Tours were destroyed. There was also a flooding of the valley of the Loire following the breaking of one of its banks downstream from Orléans. No doubt all these events were interpreted as portents of future misfortunes.
4. Referring possibly to the effect on his health of excessive study while at the École Militaire which in turn may have been responsible for the serious illness of 1784–5.
5. He is probably referring to Bézout's *Théorie générale des équations algébraiques* (Paris, 1779).
6. In the introduction to the posthumous (1831) edition of Fourier's *Analyse des équations déterminées* Navier refers to a meeting of a *séance* of the Académie Royale des Sciences on 9 December 1789 at which Fourier 'commenced to read a memoir on algebraic equations'. This could have been the memoir referred to here. According to Navier there is no further reference to it in the minutes of later *séances*. But Fourier himself in a letter of 11 April 1816 to the president of the Académie des Sciences refers to a memoir on which a report had been made, 'twenty-six years ago [i.e. in 1790] by Messrs. Cousin and Monge who particularly desired to encourage my zeal'. This report would have been on the memoir referred to by Navier.
7. He would seem now to be referring to the paper on algebra sent to Montucla for an opinion by Bonard. (See above Letter I, n. 1.) The circumstances of Montucla's 'falling out with learned analysis' are unknown.
8. Pascal's early 'claims to immortality' would have been known to all aspiring French mathematicians. In the case of Newton—that unavoidable English phenomemon—Fourier would have read of the story of the apple in Voltaire (*Éléments de la Philosophie de Newton*) while Newton himself relates the history of his early researches in light at the beginning of his first paper to the Royal Society.

III

Fourier to Bonard, September 1789

St. Benoit, Sunday, September, 1789.

Sir,

On this occasion I shall no longer complain of your silence; I must declare myself since you have done so. This correspondence with which you yourself had charmed me was no more than a pleasing chimera; but what is there that cannot be consoled by time and reason?

The wish to publish what I have discovered in algebra, the long silence of M. Montuclas,[1] and perhaps the fear of being forestalled, all this has recently induced me to make some attempts to broadcast those truths which I believe are important and of which Bonnardot[2] promised to communicate an abstract to M. Monge,[3] and even to have them published. I recalled that you might have been able to present your copy to M. Legendre,[4] for I remember you mentioned the matter to me. You would oblige me by informing me, as soon as your affairs will permit you, if M. Legendre has read this paper; and if so what is his answer. I should like to know before offering the abstract I have been telling you of to M. Monge.

If you were to put between your reply and my letter too long an interval I might perhaps lose the opportunity which is going to present itself to send what I have written to Paris.

I am your very humble and very obedient servant,

Fourier

P.S. Kind regards to Mme Bonard. It is not with her that I am annoyed. M. Aubry[5] senior passed through here the day before yesterday. He is a friend of M. Montuclas. He has promised to talk to him of my memoir.

Notes

1. For the long silence of M. Montucla see Letters I, II above.
2. He has left no trace behind.
3. Monge, Gaspard (1746–1818). Educated at the oratorian schools at Beaune and Lyons, he was destined for the Church but withdrew on the advice of his father and went instead as a draughtsman to the military engineering school at Mézières. There his talent was soon recognized and he was appointed to the chair of physics in 1768. He was elected an associate of the Académie des Sciences in 1789. He became an ardent revolutionary and served as Minister of Marine from August 1792 to April 1793. Later he was a leading member of the small group of scientists including Berthollet, Guyton de Morveau, and Fourcroy who put their talents at the disposal of the Committee of Public Safety

during the dark days of 1793–4. He played a major part in the foundation and early organization of the École Polytechnique where he was also an inspiring teacher. In 1797 he was sent to Italy with Berthollet to supervise the 'collection' of works of art. There he was recognized by Napoleon who as a young officer had been treated graciously by Monge while the latter was Minister of Marine. Berthollet and Monge were later entrusted by Bonaparte with carrying the treaty of Campo-Formio to Paris. A member of the Egyptian Campaign, he was the driving force behind the Institute of Cairo of which he was the first president. With Berthollet he again supervised the collection of works of art and other valuables. He accompanied Bonaparte on the Syrian Campaign, and was fortunate to recover from a serious illness at the siege of Acre. He returned to France with Bonaparte in 1799 to take up his position again in the École Polytechnique which he always regarded (with justice) as his own particular creation. He was forced to accept various honours from Napoleon including the title of count and a seat in the senate. At the First Restoration his part in the Revolution was overlooked, but on the Second Restoration it was remembered that he had been a minister at the time of the execution of the King and he was expelled from the Académie des Sciences and forbidden to enter the École Polytechnique. Heartbroken by these measures and the fall of Napoleon his last years were spent in a state of deep melancholia with gradual loss of powers. Monge was effectively the creator of descriptive geometry, a method of representing three-dimensional bodies on a plane, and he also did distinguished work in the theory of surfaces. Apart from Fourier his pupils included Dupin, Servois, Hachette, Biot, and Poncelet (*Gde. Encycl.*; Aubry; Taton (1)).

4. Legendre, A. M. (1752–1833). He studied at the Collège Mazarin and thereafter devoted himself entirely to mathematics especially the works of Euler which he is said to have known by heart. On the recommendation of d'Alembert he obtained a chair at the École Militaire in Paris. He was a member of the Académie des Sciences (1783) and of the Bureau des Longitudes. He made important contributions to the theory of numbers and to analysis, especially to the theory of elliptic and Eulerian functions. His *Éléments de Géométrie* (twelve editions 1794 to 1823) and his *Théorie des Nombres* (2 Vol. 1830) became classics (*Bio. Gen.*; *Gde. Encycl.*; see also Beaumont).
5. This could have been J. B. Aubry (1756–1809), a member of the Benedictine Congregation of St. Vannes, and the author of a number of books including *l'Anti-Condillac, ou Harengue aux idéologues modernes* (Paris 1801) (Bio. Univ.).

IV

Fourier to Bonard, October 1793

This 7th day, 2nd month,
2nd year of the French
Republic one and indivisible.

Equality or Death.

Joseph Fourier, national agent, to citizen Bonard.

I beg you, my very dear fellow-citizen and colleague,[1] to do me two equally important services immediately on receipt of the present letter.

In the first place, I would like you to visit citizen Roux,[2] the mathematician, to find out from him if he has received a letter from me in which I requested him to let me have about 400 francs: I have spent much more than I anticipated on my journey, and out of 550 francs, I only have 5 left at the most. This amount will not suffice for the remainder of my journey. I anticipated this and had applied to citizen Roux; I do not know if he has fulfilled this commission. It could be that the registered letter has remained at Orléans which I left quite a time ago.

If citizen Roux has not been able to render me this service, I beg you to do it for him, at least for half the sum. And in the event of him having sent it to Orléans you could inform me accordingly.

However, in this latter case, I would beg you still to send me some additional money no matter what the amount so that I may be able to wait, or rather since it looks as if I shall not return to Orléans, I shall write immediately to have the letter returned to Auxerre, where I shall go, moreover, without delay for my mission is finished and with every possible success. The horses and military equipment will arrive directly.

I pass on to the second matter: you will have heard that the Department of Loiret is not absolutely quiet and that the town of Orléans is somewhat disturbed: I played some part in this matter and I behaved in it in conformity with the principles of the Revolution.

I realized how things stood with regard to certain difficulties which I resolved with too much success not to irritate my adversaries. I have been informed that they are going to denounce me to Ichon[3] by whom I was delegated. I should like to know the details and consequences of this denunciation which is no more than a trifle for me and which will, I hope, in time rebound dreadfully against its authors.

I have written about this to Milon.[4] I should like to know if he has received my letter, and the attitude taken by Ichon. I was expecting, I must confess, to be recalled temporarily. But now there is no longer time for that since everything is completed. Please deal with this matter, I beg you, with the speed of lightning. I am accustomed to this language, I who for fifteen[5] days have been hurrying on night and day.

The most urgent thing, you will agree with me, is the money; let me have it by return of post. That which remains to me will not last for two days, since I have to feed two horses and my coachman. If citizen Roux has already made the advance I have demanded of him, I beg you to tell him that it will be returned to him as soon as I arrive. I thank you in advance for all the trouble I am about to give you. Your kindness leads people to importunate you and you will add this service to all that I owe you.

Fourier.
National agent in the department of Loiret,
at Montargis, at the Angel Hotel.

Notes

1. Bonard and Fourier were both on the staff of the college at Auxerre and also both belonged to the revolutionary committee.
2. Roux, Jean Louis (1769–?). Born at Cluny, he is given as professor in charge of the sixth class in Dom Rosman's list of 1790 where he is styled as an abbé. He was one of those who continued in the school under Balme's directorship after the dismissal of Dom Rosman and the other professor–priests. He was appointed one of the teachers in the new system of education in the commune of Auxerre on 26 Brumaire Year III and in 1795 was called to the École Normale. He was appointed professor of physics and chemistry at the foundation of the École Centrale in 1796. In 1804 he became professor of mathematics at the École Secondaire a position he still occupied in 1823. Following a visit to Auxerre, the Inspector General of Universities, Joubert, reported that Roux was first rate but that '*il ne connait pas le ciel*'. He was, however, very careful to hide it (*Arch. Yon.*; Cestre (3); Tessoneau).
3. Ichon, Pierre-Louis (1757–1837). He entered the congregation of the Oratoire and became professor of theology at the College of Condon in 1783. He was elected deputy of Gess for the Legislative Assembly and for the Convention where he voted for the immediate execution of the King. He was sent on a mission to oversee recruitment of the *levée* of 300 000 in Gess and Landes in March 1793. After several other missions (including that to Yonne) he returned to the Convention after 9 Thermidor where he remained faithful to the Mountain, defending Jagot against Merlin. He filled several administrative positions under the Directory, the Consulate, and the Empire. In spite of being a regicide, and of signing the *Acte Aditionnel* during the Hundred Days he escaped exile* by reason of 'powerful protecting interests' (Kucinski).

   Like so many other ex-ecclesiastics in the Revolution—it is not necessary to go beyond Goyré-Laplanche for another, even more extreme example—Ichon showed himself a decided enemy of the clergy both regular and secular, especially of the non-juring priests. A curious example of this anti-clerical bias is provided by an account of Ichon's contribution to a discussion in the Directory of the department of Yonne on 25 Brumaire Year II (i.e. six days after the *séance* at which the decree confirming Fourier's dismissal from his commission was promulgated) relating to the destruction of the *fleurs de lis* sculptured on the arches of the vaults of the cathedral of St. Etienne at Auxerre.

   > Citizens [said Ichon], one of our most important duties is to remove from the sight of our fellow citizens all signs of priestly idolatry; for too long the people have been both the vitctim and the dupe of all these vain marvels thought up by the priests to propagate their superstitious empire. It is for you, in whom the people place their trust, to obliterate the baubles of a religion disfigured by their ambitious hypocrisy. I am going to tell you something of which you are no doubt unaware, for I scarcely remember it myself. I was a priest, but lo, scarcely ordained, I recognized the error into which I had been led, and in the space of six or seven years I carried out the involved practices of that perverse institution no more than ten times (*Arch. Yon.*; *Bio. Gen.*; *Bio. Univ.* (Ed. 1858); Kucinski).

   * According to *Bio. Univ.* (Ed. 1858) he was forced into exile in 1816 and returned in 1830.
4. Was probably the Paul Milon who headed the list of signatories of the address of the Popular Society of Auxerre to the convention demanding the trial of the King. Professor of the college of Auxerre under Balme's principate between August 1793 and Messidor Year II, he was appointed one of the *instituteurs* to the new system of education in the commune of Auxerre in Brumaire Year III. He was dismissed from his position in Prairial Year III as a former Jacobin and was not 'reintegrated' till Ventôse Year IV. In July 1796 he was appointed co-librarian in the new École Centrale. A certain Milon is said (Cousin, p. 32) to have been a close relation of Fourier (*Arch. Yon.*; Cestre (3)).
5. Implying that Fourier left Auxerre on 22 Vendémiaire, that is the day before the promulgation of Ichon's order of the 23rd.

V

Fourier to administrators of the Department of Yonne, January 1794

This 24 Nivôse, Year II of the
French Republic, one and
indivisible.

Equality, Liberty.

Joseph Fourier to the Administrators of the Department of Yonne.

Citizens, the National Convention has desired that there should be a public library in all the principal department towns.

This wish has been fulfilled in the majority of the divisions of the Republic.

The administration proposes to appoint a person to direct this establishment in the commune of Auxerre.

Joseph Fourier, professor of eloquence, presents himself to fill this place.

Domiciled in this commune he has successively occupied there the public chairs of mathematics, history, eloquence, and philosophy. Having devoted himself since childhood, and possibly with too much ardour, to the study of the exact sciences, passing his nights in instructing himself, and his days instructing others he has need of several years repose.

He has no inheritance except time and no acquired wealth except public esteem. His morals are beyond reproach and his civisme, sufficiently well-known, is also attested by the election of the people who have placed him in a public position. The place in question would suit a man of letters residing at Auxerre and he solicits it as a national recompense.

He will only suspend his course of public eloquence when a citizen agreeable to the administration has presented himself to replace him.

VI

Fourier to Bonard, January/February 1795

[Notes on the École Normale and the persons attached to that Establishment]

The École Normale holds its sessions at the *Jardin des Plantes*,[1] in a middling-sized place of circular shape; daylight only enters from above; the pupils, who are very numerous, are seated in rows on the tiers of a very high amphitheatre; there is not room for everyone, and every day there are a fair number who find the door closed; if one is obliged to leave during the session, one cannot enter again. Only pupils are admitted, on presentation of their cards to the officer on guard or the sentry. Some exceptions are made, however, in the case of a small number of loyal citizens and of several women. At the back of the room, and within an enclosure separated by a railing, are seated several Parisian scientists and the Professors. In front, and on a slightly higher platform are three armchairs for the professors who are to speak and their assistants. Behind them, and on a second, still higher platform, are the two representatives of the people Lakanal[2] and Deleyre,[3] in the uniform of deputies on detached service. The session opens at 11 o'clock when one of the deputies arrives; there is much applause at this moment and when the professor takes his place. The lessons are almost always interrupted and terminated by applause. The pupils keep their hats on, the professor who is speaking is uncovered; three quarters of an hour or an hour later, a second professor takes his place, then a third, and the usher announces that the session is ended. The names of the professors are familiar to the men of letters who attend the sessions and conferences. I have noticed Cousin,[4] Lalande,[5] Brisson,[6] the bookseller Panckoucke,[7] several professors of the Lycée.[8] Several are brought in official carriages or with the deputies; the professors never come any other way. Here are some particulars about the professors: these *minutiae* may appear superflous, but I am writing them because the papers give no account of them. Lagrange,[9] the first among European men of science, seems to be between 50 and 60 years old. He is however younger; there is a dignity in his features and a delicacy in his countenance: he seems a trifle thin and pale; his voice is very weak, except when he becomes animated; he has a very pronounced Italian accent and pronounces s like z; he is very modestly dressed in black or brown; he speaks very familiarly and with some difficulty; there is in his speech the hesitation and simplicity of a child. Everyone sees clearly that he is an extraordinary man, but it is necessary to have seen him to realize he is a great man. He only speaks at the conferences, and there are certain of his phrases which might excite derision. He said the other day: 'There are still on this matter many important things to say, but I shall not say them'. The pupils, who for the most part, are incapable of appreciating him, give him a rather poor reception but the professors make up for it. Laplace[10] who is also like him [Lagrange] professor of analysis had been nominated at Melun a pupil of the École Normale and had accepted [the nomination]; the government has repaired this administrative error.[11] Laplace is among the first rank of men of Science, he is known in Europe as an excellent mathematician, physicist, and chemist; he seems quite young, with a weak though distinct voice, and he speaks with precision, but not without a certain difficulty; he has quite an agreeable appearance and is dressed very simply; he is of medium build. The mathematical teaching he gives has nothing extraordinary about it and is very rapid.

Haüy,[12] former abbé[13] is extraordinarily modest and simple; he is not old; his dress is still almost that of a churchman moreover he refused to take the oath. His speech is very distinct, he makes himself perfectly understood and speaks with great elegance and ease. It would be impossible to express oneself better. It is said that he knows his lecture by heart. It seems that he reads part of it, although it is not always easy to be sure of this for the professors are far away and they always have their lecture notes in front of them. He is so timid that if anyone interrupts to ask for an explanation he becomes confused and answers badly or not at all. It is not that he is not very learned, and if he does not shine with the genius of the first two (professors), he has at least all the brilliance of method and the display of the most elegant demonstration.

D'Aubenton[14] is an old broken man who is almost carried to his chair; he reads and speaks alternatively and is understood by no-one. There are some repetitions in his lessons, but they are full of reason and knowledge. There has never been a naturalist more completely and wisely learned. There is a touch of good humour in his speech which adds to the respect which he inspires.

Berthollet[15] is the greatest chemist we have, either in France or abroad: he is not old and has a rather ordinary appearance. He only speaks with the most extreme difficulty, hesitates and repeats himself ten times in one sentence, and seems to find difficulties in the least important details of an experiment. His course is only understood by those who study much or understand already, and it is for this reason that he displeases the great majority. His course is a collection of useful dissertations, very wise and very learned: he has much difficulty in making himself understood.

Monge[16] speaks in a loud voice, he is active, ingenious, and very learned. As one knows, he excels in geometry, physics and chemistry; the science on which he lectures is presented with infinite care, and he expounds it with all possible clarity. One finds even that he is too clear, or rather that his method is not sufficiently rapid. He will give private lessons in practical work. He speaks very familiarly, usually in a precise way. He is not only to be recommended for his deep knowledge, he is said to be very admirable in all public and private respects. His appearance is very ordinary.

Thouin[17] is a very learned naturalist; he is now in Belgium, where the government makes use of his talents.[18]

La Harpe[19] is well known, and speaks with great elegance and taste; he has not the charlatan tone with which one can reproach several others, but he has a bantering and decisive way of speaking; he speaks without having any hint of constraint and he has a very clear voice. A very learned man of letters, he makes no display of his knowledge, and only shows it when appropriate, does not try, like others, to vaunt his art above all others, and makes himself heard with pleasure by people of good taste. He has made no secret of being a professed partisan, as one can see in his programme, and is only approved in that respect by the crowd. The unjust persecution which he says he underwent is not a sufficient excuse, for one must be tolerant, even with regard to those who are not always so themselves. Nevertheless, I find that of all the professors he is the one who speaks the best.

Volney[20] is a rather young man, very well dressed, tall with a very agreeable appearance. I know little of his writings.[21] He speaks easily and chooses his words very carefully; his speech is slow and he seems to take a pleasure in it. If knowledgeable people are not flattered on the score of his taste, they are at least astonished by the glitter of his diction. He has tried to fill his course with too much philosophy, and in the midst of these brilliant accessories, the principal object of his teaching disappears.

Sicard[22] is well known as a teacher of deaf-mutes. Of short stature, still young, he has a strong voice, distinct and vibrant. He is ingenious, interesting, active and knows how to keep the attention of a large audience. He pleases the crowd who bring down the roof in applause. He praises his subject, his method and his principles, and at every turn talks of the natural man, whom he claims to be deaf and dumb. He is a man of great wit, without genius, who seems to be very sensitive and, is (I think), in reality modest, but he has been beguiled by some sort of grammatical system which he claims to be the clue to the sciences. He often speaks for a long time and pompously, and there is something capricious in his accent and diction. His theory of grammar, which is brilliant in certain respects, is one of the craziest I know of. In spite of this there [is] talk of adopting it, and even prescribing it in all the schools of the Republic. If this comes about we shall have something to laugh about. Apart from this, Sicard is full of enthusiasm and of patience and is a paragon of all the virtues, but he is mad: that makes me think that he pleases the ladies, although he is small and rather ugly.

Mentelle[23] is known at Auxerre.[24] His lessons are extremely informed and have nothing in them worthy of the institution; he talks reasonably, as far as I can judge, for I scarcely every listen to him. Buache[25] is a very well known geographer who speaks very badly and gives some indication of a knowledge of the subject. Garat[26] is a rather young man of medium height, and of a rather agreeable appearance. He has a loud voice with a very lively and oratorical tone. His speech is loud and eloquent, he has less taste than La Harpe but more warmth and vivacity. As for the substance of what he says I find his ideas a trifle fanatical: he talks of nothing less than the perfection of human organization and of opening up ways to the human spirit hitherto unknown. He greatly and almost exclusively praises Bacon, Locke, and Condillac of whom he is an enthusiastic admirer. However, one would have to be unfair to deny Garat superior and extraordinary talents: he is, after La Harpe, the one I most like to hear talk.

You will find me very bold to dare thus to judge these superior men, but I only give you the first impressions made on me, and I shall admit my errors as I recognize them. In another note[27] I shall give my opinion of the pupils, I shall speak of them with that liberty of thought which I have always cherished and which I shall never give up. I shall also send a note of the books which could most usefully steer education in the direction which the government wishes to give to it today.

Notes

1. Founded in 1635 the *Jardin des Plantes* had at first been a centre for the culture and study of medicinal plants. With the appointment of Buffon as director in 1739 the field of study was gradually extended to the whole of biology. It was reorganized by the Convention's law of 10 June 1793 and had had its name changed officially to *Muséum d'Histoire Naturelle* under which name it had been opened to the public on 7 September 1794. But the old name lingered on.
2. Lakanal, Joseph (1762–1845). Educated by the 'doctrinaires' he entered their congregation and taught in various colleges. Elected to the Convention for the department of Ariège he voted for the immediate execution of the King without stay or appeal to the people. He was elected to the Committee of Public Instruction in January 1793 and was one of the most active and influential of its members. He was largely responsible for reorganizing the *Muséum d'Histoire Naturelle*. He instituted a competition for composition of books for public instruction and presented a plan for national education (26 June, 1793). On the replacement of the Committee of Public Instruction on 6 July he was elected one of six members of the new committee. Elected secretary of the Convention on 21 August 1793 he had the Écoles Militaires suppressed, and decreed (15 September) the setting up of three progressive degrees of education, universal, secondary, and special. He returned to the Committee of Public Instruction after 9 Thermidor. On 28 October 1794 he presented his report on public education, and on 30 October decreed the formation of the École Normale. On 12 November he was named with Sièyes representative of the Convention at that school and on 18 November he had the law of public education passed. On 25 February 1795 he presented a project for the establishment of Écoles Centrales. He co-operated in the establishment of the Institut being himself admitted to the Second Class. After the *coup d'état* of 18 Brumaire he took over the chair of ancient languages at the École Centrale de la Rue St. Antoine. In 1807 he became inspector general of weights and measures. At the Restoration he was dismissed from his employment and from the Institut, and was proscribed as a regicide. He sought refuge in the United States becoming president of the University of New Orleans and did not return to France until 1833 when he was readmitted to the Academy of Moral and Political Sciences in succession to Garat (*Bio. Gen.*; *Gde. Encycl.*).

3. Deleyre, Alexandre (1726–97). Educated by the Jesuits he became acquainted in Paris with Rousseau, Duclos, Diderot, and d'Alembert and contributed an article on Fanaticism to the *Encyclopédie*. Elected to the Convention for the Gironde, he voted for the death of the King. He was elected to the Council of Ancients in 1795 in which year he also became a member of the Second Class of the Institut. He was the author of several comedies and published a French translation of an English analysis of the philosophy of Bacon (*Bio. Gen.*; *Gde. Encycl.*).
4. Could have been: Cousin, J. A. J. (1739–1800), professor of physics at the Collège de France. Became a member of the municipality of Paris in 1791 and later sat on the Council of Ancients. He was elected to the Académie des Sciences in 1772 and was the author of a number of well-known text books including '*Leçons sur le calcul différentiel et le calcul intégral*' (Paris 1777). *Or* Cousin, C. Y., known as Cousin d'Avallon (1769–1840). Historian and compiler, author of a large number of books including many collections of anecdotes (*Bio. Gen.*).
5. Lalande, Joseph Jérôme (1732–1807). Educated by the Jesuits he changed from Law to Astronomy following a visit to the observatory of Paris. On returning to Paris in 1753 after a mission to Berlin he became a member of the Académie des Sciences. In 1760 he succeeded Deslisle as professor of astronomy at the Collège de France where his lectures attracted pupils from all parts of Europe. He directed the Paris observatory from 1768 until his death. He composed many *éloges* for the Académie des Sciences. His desire for public recognition rendered him increasingly eccentric towards the end of his life. He was the author of many works including his *Traité d'Astronomie* (1764) and his *Histoire céleste française* (1801). His nephew Michel Lalande (1766–1839) was also an astronomer who devoted himself more exclusively to astronomical tasks than his uncle whose deputy and later successor at the Collège de France he was, and with whom he collaborated in the *Histoire céleste française* (*Bio. Gen.*; *Gde. Encycl.*; see also Aimable).
6. Probably J. M. Brisson (1723–1806). Naturalist and physicist. He acted as assistant to Réaumur in his youth and succeeded Nollet in the chair of physics

in the Collège de Navarre. He was a member of the commission of weights and measures. Elected a member of the Institut in 1795 (*Bio. Gen.*; *Gde. Encycl.*).

7. Panckoucke, Charles Joseph (1736–98). He continued the trade of erudite bookseller and printer commenced by his father André Joseph (1700–53) of Lille. An enlightened and wise editor he attached himself in Paris to the ablest savants and literary men of the day with whose help he was able to undertake important publications including the *Encylopédie Méthodique* (1781–1832), the so-called Kehl edition of Voltaire revised by Beaumarchais, the works of Buffon, and the memoirs of the Académie des Sciences. Under his editorship the *Mercure de Paris* at one time counted no less than 15 000 subscribers. He founded the *Gazette Nationale* or *Moniteur Universel*, from its first appearance in November 1798 the unwearying and largely faithful witness of the wayward course of the Revolution. His son Charles (1780–1844) continued the great tradition of his father and among many other important works was publisher of the revised edition of the *Description of Egypt* (1820–30) (*Bio. Gen.*; *Gde. Encycl.*).
8. Almost certainly the Lycée founded in Paris in 1787 by Pilatre de Rozier for teaching literature and sciences. It numbered among its professors at various times Fourcroy, Chaptal, Thénard, Cuvier, Guinguiné, La Harpe, and Biot. Later (1803) it took the name 'Athenée de Paris'. Alternatively, but less likely, Fourier could be referring to the less famous Lycée des Arts, founded in 1792, whose title was changed to 'Athenée des Arts' in 1802. Unlike the Lycée, the Lycée des Arts was exclusively concerned with scientific subjects, its main object being the organization of courses of public lectures and the recognition by means of prizes and medals of discoveries useful to industry and the arts. Prominent early members were Lavoisier, Berthollet, Fourcroy, Lalande, and Lamarck (*Gde. Lar.*; *Gde. Encycl.*; Crosland).
9. See above Letter I, n. 12.
10. Laplace, Pierre (1749–1827). Son of a poor cultivator, he had the good fortune to encounter a first class teacher at the University of Caen, Christophe Gadbled (1731–82) who was imbued with that strict sense of rigour essential to the serious study of mathematics. Later he returned to the École Militaire of his native town of Beaumont-en-Auge from whence he proceeded to Paris with letters of recommendation for d'Alembert. These were at first ignored, but after Laplace had written d'Alembert a letter which was in reality an original mathematical memoir the latter immediately summoned him and said 'Sir, you see that I do not bother much about recommendations: you have no need of them . . .'. Soon after d'Alembert had Laplace appointed professor of mathematics at the École Militaire in Paris. In 1773 he entered the Académie des Sciences and he also held positions as examiner at the school of artillery (where he succeeded Bézout) and at the Bureau des Longitudes (of which he ultimately became president). He was a member of the Metric Commission, and of the Committee of Public Instruction and traversed the Terror safely in spite of his earlier close friendship and collaboration with Lavoisier. Apart from lecturing at the École Normale (Year III) he played an influential role in the early years of the École Polytechnique, being a foundation member of the jury of examiners. Later he was president of the *Conseil de Perfectionnement* of the school. After the *coup d'état* of 18 Brumaire Laplace was appointed Minister of the Interior only to be replaced some six weeks later by Napoleon's brother

Lucien. In his memoirs Napoleon describes how Laplace quickly disappointed his hopes and proved himself totally unfitted for the position:

> He never grasped any question from the right end: everywhere he searched for subtleties, had nothing but hypothetical ideas, and finally carried the spirit of the infinitely small into administration.

Later Laplace was created a senator and count of the Empire, though this did not prevent him signing the act of deposition of Napoleon. Towards the end of his life, in 1826, he incurred much odium among the more liberal-minded of his colleagues in both the Académie des Sciences and the chamber of peers by his support for the infamous press law 'of justice and love'. Like Newton, however, any personal defects in Laplace were overshadowed by his single-minded devotion to science and the towering nature of his achievements in his chosen fields of study, especially in celestial dynamics. Here he vastly extended and refined all previous applications of the theory of gravitation, and greatly reduced the number of cases where theory and observation failed to agree, thus (ironically) paving the way for Einstein's general theory of relativity. Apart from celestial dynamics he also made a major contribution to the theory of probability in which his treatise was the point of departure for all later work in the subject for the remainder of the nineteenth century. Laplace's approach to mathematics was in sharp contrast to that of his friend and colleague Lagrange. For the latter mathematics was a world in itself in which question of elegance, clarity and harmony were primordial, whereas for Laplace mathematics was above all a tool to help unlock the secrets of nature. But he was at one with Lagrange (and Newton) in his humbleness before Nature, remarking on his death bed: 'what we know is a small thing: what we do not know is immense' (*Bio. Gen.*; *Gde. Encycl.*; Andoyer; Hahn).

11. This story could well have been apocryphal. But it epitomizes that undue, and indeed unnecessary, regard for authority which seems always to have characterized Laplace. In the gentle sarcasm of Fourier's account, and the placing of Laplace among the first rank of savants behind Lagrange, the first of European savants, there may be detected the beginning of an antipathy on Fourier's part which—if Cousin is to be believed—eventually became fairly strong, although Fourier was probably always careful to hide it, at least until he had become permanent secretary to the Académie des Sciences, and which in any case he would never have allowed to cloud his respect for Laplace's magnificent achievements in theoretical physics.
12. Haüy, René Just (1743–1822). Educated at the colleges of Navarre and Cardinal Lemoine. Through attending the course of natural history of d'Aubenton he became interested in mineralogy and later made fundamental contributions to crystallography which entitled him to be regarded as the father of that subject. He gave lectures on his new theory of crystals at the college of Cardinal Lemoine before distinguished audiences which included Lagrange, Lavoisier, Laplace, and Berthollet. Under the Revolution he first lost his benefice on refusing to take the oath of allegiance to the State, and later his university position. After 10 August he was arrested as a non-juring priest. Geoffroy Saint Hilaire, who had been one of his pupils, determined to free Haüy and with the aid of members of the Académie des Sciences and the *Jardin des Plantes* succeeded in obtaining an order for his release. But it was only with great difficulty that he managed to persuade Haüy to leave prison a few days before the massacres of 2 September. He became a member of the commission

of weights and measures in September 1793 and keeper of the *Cabinet des Mines* in August 1794. He was elected to the old Académie Royale des Sciences in 1783, and to the Institut on its foundation in 1795. His *Traité de Minéralogie* was published in 1801 and the next year he became professor of mineralogy at the *Muséum d'Histoire Naturelle* (*Bio. Gen.*; *Gde. Encycl.*; Lacroix).

13. Fourier himself is styled abbé on Dom Rosman's list of professors at the École Royale Militaire Auxerre in 1790. Although this is the only occasion on which he seems to be given this title in the records, it fits in well with his public avowal on 21 April 1790 (see above chapter I, p. 13). But if he was in fact an abbé like Haüy, unlike Haüy he would have had no compunction in taking the oath of allegiance to the State. Perhaps these thoughts passed through Fourier's mind as he wrote of the former abbé in the almost ecclesiastical dress, and Bonard on reading the letter might well have recalled how a few years previously this same [abbé] Fourier had christened his eldest child Joseph Antoine René Bonard whose first name Joseph was no doubt given him for Fourier.

14. D'Aubenton, L. J. M. (1716–1800). Educated by the Jesuits, he became assistant to Buffon in the composition of his *Histoire Naturelle*. He entered the Académie des Sciences in 1744 and was Professor at the Collège de France and the *Jardin des Plantes*. He was one of the first to realize the importance of the study of comparative anatomy for the determination of fossils, a work carried on by his pupil Cuvier. Entirely without worldly ambition, he devoted himself wholly and exclusively to his subject. He was one of the most conscientious lecturers at the École Normale giving sixteen lessons packed with detail and laced with a certain amount of unconscious humour including his memorable opening words: 'we are all here gathered together by a decided taste for natural history' (*Bio. Gen.*; *Gde. Encycl.*; Alain).

15. Berthollet, Claude Louis (1748–1822). He graduated in medicine and in 1780 became one of the doctors to Madame de Montesson the mother of the Duke of Orléans (Philippe Égalité). Thereafter he devoted himself increasingly to the study of chemistry, in which he at first upheld the phlogiston theory. The seventeen memoirs which he published in support of this theory in the Académie des Sciences marked him out as one of the most determined opponents of the new views of Lavoisier. But in 1783 he made his *amende honorable* before the Académie des Sciences of which he had become a member in 1780. Thereafter he was one of the principal collaborators in the revolution in chemistry initiated by Lavoisier. He made many original contributions to both inorganic and physical chemistry. He was president of the scientific commission set up by the Committee of Public Safety to study problems of physics, chemistry, and mechanics important for national defence. In 1797 he was sent on a mission to Italy with Monge to supervise the 'collection' of works of art. He performed the same function in Egypt. In the revolt in Cairo in 1799 his firmness (and that of Monge) under great danger contributed much to the saving of the Cairo Institute with all its instruments and collections. He prospered greatly under the Empire becoming a senator and grand officer of the legion of honour. In 1814 he voted for the deposition of Napoleon out of horror of war, and was rewarded by Louis XVIII with the title of count and a seat in the Chamber of Peers. In his house at Arcueil he entertained many visiting scientists including Davy, Watt, and Berzélius. In 1807, in company with Laplace, he founded the short-lived but very influential *Société d'Arcueil* (*Bio. Gen.*; *Gde. Encycl.*).

16. See above, Letter III, n. 3.

17. Thouin, André (1747–1824). At the age of seventeen he replaced his father as chief gardener at the *Jardin des Plantes*, increasing the cultures and greenhouses and making many contacts with botanists in similar establishments in other countries. He was elected a member of the Académie des Sciences in 1786, and became professor at the *Muséum d'Histoire Naturelle* in 1793 (*Gde. Encycl.*).

18. A somewhat malicious reference by Fourier to Thouin's activities in Belgium and Holland where he had been appointed by the French Government as one of their commissioners to oversee the 'collection' of works of art. He later performed the same function in Italy.

19. La Harpe, Jean Francois (1739–1803). Soon after completing a brilliant course of studies at the Collège d'Harcourt he was imprisoned for verses lampooning various members of the college. This harsh treatment, added to the grinding poverty of his early years, embittered his spirit. After writing for a time for the theatre where the great success of his early play Warwick was not repeated, he turned to his true profession of literary and critical studies. In 1776 he was elected to the Académie Française where in 1780 he read an *éloge* of Voltaire whose affection and interest he repaid by a somewhat shocking flippancy and lack of deference. He opened a course of literature at the Lycée de la Rue St. Honoré in 1786, which, apart from a period spent in prison, he continued till 1798. This course, which was enormously successful, was the first example of literary teaching in France and contained a particularly brilliant, if somewhat superficial, description of French literature in the seventeenth century. In 1793 he came out strongly in favour of the Terror in whose honour he composed an ode. In spite of this he was imprisoned as a suspect in April 1794. Entering prison as a confirmed Voltairian he left it after 9 Thermidor as a militant Catholic turning savagely on his former heroes and principles, and he played a prominent part in the Thermidorians ruthless anti-Jacobin press campaign of 1794/5. The very favourable impression made on Fourier at the École Normale (Year III) by La Harpe's excellent delivery is in sharp contrast with the impression evidently made on the stenographer whose record of his lectures was judged by Alain (p. 183) as 'very mediocre, without order or method, and containing nothing practical' as opposed to the order and clarity of the records of the geographers Buache and Mentelle whom Fourier in turn found deadly dull (*Bio. Gen.*; *Gde. Encycl.*).

20. Volney, C. F. Chasse Boeuf, Comte de (1757–1820). Son of an advocate he went to Paris after completing brilliant classical studies and studied first law then medicine. But he was soon captivated by the then prevalent philosophical discussions about oriental languages and civilizations and the study of antiquity, and this led him to spend an unexpected legacy on travels in Egypt and Syria from 1782–7. His description (1787) of these travels brought him great fame. On the outbreak of the Revolution he was called first to the States General, and later to the Constituant Assembly where he played a distinguished part. His attachment to the Girondins led to his imprisonment for a time during the Terror. He was released after 9 Thermidor and was charged with a course of history at the École Normale. Sent to the U.S.A. in 1795 he was at first well received by Washington but was later accused by John Adams of being a spy sent to prepare for the return of Louisiana to France. He returned to France in 1798.

After 18 Brumaire he was at first a supporter of Napoleon, having known him previously for his republican sympathies, and he was created a senator. Later he became increasingly critical of the dictatorial tendencies of Napoleon. He offered to resign in 1804 when the Empire was proclaimed. Napoleon tried to humour him by electing him to the Legion of Honour but until the end of the Napoleonic era Volney in company with Destutt de Tracy, Lanjuinais, and other '*idéologues*' continued a decided critic of the Napoleonic régime.

Created Count by Louis XVIII at the First Restoration he did not rally to Napoleon during the Hundred Days and after the Second Restoration played little or no part in politics, devoting all his time to the study and publication of works on languages. A member of the second class of the Institut from 1795 onwards, he was elected to the Académie Française at the time of the suppression of the second class. He left money to the Institut for the Prix Volney for the study of languages and comparative grammar (*Bio. Gen.*; *Gde. Encycl.*).

21. Volney's best known writings prior to 1795 were his *Voyage en Egypte et Syrie* (1787) and his *Ruines ou Méditations sur les Révolutions des Empires* (1791), especially the latter which was a best-seller and very influential in the Romantic Revival in France.

22. Sicard, Roch Ambroise, Abbé (1742–1822). He entered the Church, and having been initiated in Paris into the methods of the Abbé de L'Épée was placed by Archbishop Cicé of Bordeaux in charge of a school of deaf mutes. In 1789 he succeeded de L'Épée at the Paris school. He took the oath after the fall of the throne on 10 August 1792 but was nevertheless imprisoned as a suspect on 26 August and would have been murdered in the prison of the Abbaye during the September massacres if a certain Monnot, a watchmaker, had not covered him with his own body. He was freed on 4 September and thereafter traversed the Terror in safety. He was elected to the Institut on its foundation in 1795. After the purging of Royalist sympathizers on 18 Fructidor he escaped deportation by hiding. For some unknown reason Napoleon could not abide him and in spite of Chaptal's protection he was for a time reduced to a state of penury until his fortunes revived at the Restoration when he received many sinecures (*Bio. Gen.*; *Gde. Encycl.*).

23. Mentelle, Edme (1730–1815). He tried his hand at finance and poetry before he turned to geography and history in which subjects he became professor at the École Militaire in Paris 1760. He became a member of the Institut on its creation in 1795. His brother François-Simon (1731–99) was a well-known explorer and geographer.

24. Possibly as one of the inspectors of the Écoles Royales Militaires.

25. Buache, Jean Nicholas (1741–1825). Through his uncle the celebrated geographer Philippe Buache (1700–73) he became a tutor in geography to the sons of Louis XV and was later appointed first geographer to King Louis XVI. In this position he received a salary of 24 000 francs a year with an apartment at the Louvre. His lack of any knowledge of foreign languages often led him into serious errors in the construction of maps. He entered the old Académie des Sciences in 1781 and was elected a member of the Institut at its foundation. In spite of his close association with the crown he traversed the Revolution in safety and continued as chief geographer to King Louis XVIII under the restoration (*Bio. Univ.*; *Gde. Encycl.*).

26. Garat, Dominique Joseph (1749–1833). A lawyer by profession, he established himself as a journalist in Paris. He became a member of the Lycée on its foundation in 1786 and made a name for himself as a brilliant lecturer. He was a member of the National Assembly where he played little part in the debates but gave an excellent account of them in the *Journal de Paris*. He was nominated Minister of Justice on 9 October 1792 on the recommendation of Danton. He excused the September massacres on 22 October. He was responsible for notifying the King of the death sentence and for supervising the execution. He succeeded Rolland as Minister of the Interior. His report of 27 May 1793 which found Paris absolutely quiet a few days before the insurrection of 30 May earned him the title of the 'optimist of the Revolution'. He retired from his position of Minister of the Interior on 15 August 1793 and was arrested on 2 October but was soon released and passed through the Terror safely thanks to the friendship of Barère and Robespierre whose oratorical and literary pretensions he lost no opportunity of flattering.

He tried to save Condorcet, abandoned Robespierre on 9 Thermidor, and was himself denounced on 9 March 1795 for his apology of the September massacres, but escaped imprisonment although he was removed from his position on the Committee of Public Instruction for a time. He became a member of the Institut on its foundation in 1795 and took up his chair at the Lycée again. He was president of the Council of Ancients in 1798 and continued a staunch republican up to but not beyond the *coup d'état* of 18 Brumaire. He was rewarded by Napoleon for his support by the title of senator. He became ever more sympathetic to Napoleon, but deserted him in 1814 to work for the King. He was ignored by Napoleon on his return from Elba and equally at the Second Restoration, but was not exiled in spite of his role in the execution of King Louis XVIII, presumably because he had not voted over the question of sentence (*Bio. Gen.*; *Gde. Encycl.*).

27. This note, if it was ever written, has apparently not survived.

VII

Fourier to Bonard, March 1795

Paris 28 Ventôse, Year III
of the French Republic.

I write to you, my dear Bonard, to discover more clearly what is happening about me in the Commune of Auxerre; no-one has written to me about it yet. I have vague news that I have been accused and condemned in the sections[1] there. However disagreeable the details may be it is nevertheless important that I should be informed of them. It is stated categorically that the Abbé d'Avigneau[2] is among my denunciators and I hear all sorts of stories on this score. I would never give credence to such absurdities, and what renders this still more unbelievable is that I am said to be held up as a peculator and a drunkard. Certainly I would only laugh at all that if I did not know of what excesses[3] the armed vengeance of the factions are capable.

I beg you to transmit me some details which could help me to correct these denunciations and to forestall them if necessary. I await this sad service of your friendship for me.

I know that the assemblies of the sections, in the meeting last *décadi*,[4] decided that I should be denounced in their name and that they demand at the same time my exclusion from the École Normale. To whom is this denunciation[5] addressed? On what grounds is it based? What was its form and what result has it had up to the moment? I beg to satisfy me on these points. You could add, if you like, a notice of the discussion which preceded the decision taken, as I am assured, in the four sections. This deliberation seems to be very irregular, for before whom is the denunciation supposed to be brought? Can it be supposed that I fall under the law of 5 Ventose?[6] But it is entirely inapplicable to me. I am neither dismissed from my office nor accountable. If I were able to consider myself as dismissed from office that could only be by the letter of the former Committee of Public Safety which ordered my arrest but before 9 Thermidor. However, the operation of this law is suspended. But from another point of view, being attached to a national establishment and even employed in a specific way by the government at the Collège de France,[7] only material facts can harm me; and who will find these facts? Who can reproach me with an act unauthorized by law? I cannot believe that I shall be asked to give any financial account, unless it be of my own money, nor of the blood I have spilled, nor of the wine I have drunk. Is it then the terror I have inspired? My goodness, I cannot see that I have inspired much of it among the most

feeble creatures—among women. And if I have understood some of them, they seemed ready to make enormous sacrifices.

However, my opponents can leave it to my conscience, and I am judged by it much more rigorously than they themselves would judge. Let them take it as certain that I have done nothing arbitrarily and nothing that does not emanate directly from a law. That is enough for me to feel no anxiety under a good government. But it is perhaps not enough to satisfy myself, and so I can add that my heart was never party to the evil produced by circumstances. I voluntarily did what I thought was just and useful to the cause which I embraced: what went beyond this I did not impede, but for the most part I could not have done so without rushing to certain ruin. It will be said that I should have taken the risk rather than tolerate injustice and act as its instrument; that may be true, but at least let me be blamed only by those who would have done so themselves in my place.

There is in Auxerre one man who is justified in hating me, that is Moreau,[8] whom you know: I contributed indirectly to his arrest, but I did so in public, and I refused to be involved in legal action against him. Soon after, it was I who had him set free. Far from repenting this denunciation, I would do the same again for a man of this sort should be unmasked. Apart from this individual, I can swear by all that is most sacred that I have not contributed in any manner to the arrest of any person, that those who have experienced this misfortune ought to put it down to circumstances, and that there are several persons who are indebted to me for the tranquillity which they have always enjoyed.[9] Moreover I believe firmly that there are times of public danger when such measures are justified. Since I am not able to pretend to myself that I have not done almost everything I could without certain peril, I have a perfectly quiet conscience, and that is no small thing.

I am, as you know, much disposed to become extremely anxious and so all these rumours have greatly affected me: however, on reflection, I tell you I cannot see how my enemies can succeed, because I am supported here by persons of high repute.[10]

I had wanted to write to the section in which my domicile is situated, that of fraternity, I think; I would have presented my justification briefly, and if it had been appropriate I would have obtained permission to visit Auxerre for several days, to exonerate myself in person. Do you think it would be fitting to do this, or to write a letter to the Assembly? I am completely ready to take this action; you will tell me if you think it would be useful, also the points which need to be emphasized and which seem to have made the most impression.

I depend on your friendship for this service and I await a reply from you as soon as possible. You will tell me also the news of your family; I know that you are a father for the third time, it is an occasion for my congratulations and respects to citizen Bonard your wife.

Up to now my health has been fairly good; this miserable affair greatly disturbs me; whether it is mental uneasiness or excessive work, I am not at all well; I have been obliged to keep to my room today.

I devote myself to studying with more enthusiasm than ever, and I would be perfectly content if only I were left in peace by your part of the world. You know, perhaps, that I have been appointed director of the mathematical conferences;[11] they take place every day, it is altogether exhausting. You will sometimes see my name in the journal of the school,[12] not the most pleasing thing for me, since they mangle everything I say.

I spoke to you of a proof of the famous rule of Descartes,[13] I gave it to Laplace and Lagrange who told me they would have it published:[14] I am on very good terms with these two mathematicians, I sometimes talk with them about Auxerre. The method of organizing the Écoles Centrales[15] is still uncertain. Laplace who is on the council of the Committee of Public Instruction, still does not know if they will be organized immediately. It seems that several professors will be chosen from the École Normale, something which does not exclude those like you who already hold an appointment; it is possible that those persons who are not already instructors and those who are, but are not well enough known, might be required to come to Paris to be examined, this is Laplace's opinion, but I believe it impracticable. As to the pupils of the École Normale,[16] they will be examined here. All the indications are that the present organization of primary schools will be abolished. The number of instructors who could be called to the chairs of the Écoles Centrales is very small. That is why all those of recognized talent are sure of being appointed.

I beg you to remember me to our common friends: I salute and embrace you.

Fourier

Notes

1. The number of sections into which the commune of a town was divided depended on its size. Thus the commune of Paris had forty-eight sections whereas Auxerre had only four.
2. D'Avigneau, Abbé. He was professor of Rhetoric at the college of Auxerre in 1790 under Dom Rosman. He became a member of the *Société d'Émulation* founded by Fourier in 1790. On 22 September 1797 he was awarded the prize for poetry at the Fête of the Foundation of the Republic to the displeasure of certain extreme republicans who evidently regarded his former clerical status with suspicion (*Arch. Yon.*; Quantin; Cestre (2)).

3. Fourier is thinking of the massacres of 'patriots' which had commenced in certain parts of France, especially in the south of the country, towards the end of the previous year (1794).
4. Each month of the revolutionary calendar contained thirty days which were divided into three *décadi.*
5. This denunciation, which has been preserved, eventually reached the Committee of Public Instruction and initiated the process which led to Fourier's second arrest as described in chapter 3 above.
6. On 23 February 1795, i.e., 5 Ventôse Year III a decree had been passed on the report of Merlin de Douai that all civil and military officials who had been removed from their office after 9 Thermidor should return to the communes where they had been living before that date and remain there under the supervision of municipal authorities. As Lefebvre says, this was a law of suspects in reverse and those who were unfortunate enough, or foolish enough, to comply with its terms sometimes suffered with their lives especially in the Midi where their return to the scenes of their revolutionary 'activities' often 'marked them out for massacre' (Lefebvre (3), p. 57).
7. As one of 10 *maîtres de conférences* in mathematics at the École Normale. See Guillaume, vol. 5, p. 478.
8. He has left no trace.
9. The mother of Nicolas Davout, later Marshal of France, and Dom Rosman are two of the persons Fourier is traditionally said to have 'protected' during the Terror.
10. No doubt he is thinking of Lagrange, Laplace, and Monge, perhaps especially the latter. After the attempted insurrection of the royalists against the Convention on 13 Vendémiaire had been crushed by Napoleon's 'whiff of grapeshot', J. B. Biot,* later a colleague and enemy of Fourier in the Académie des Sciences, was one of those taken prisoner by the government forces. He owed his freedom—and possibly his life—to Monge who recognized him as one of his best pupils at the École Polytechnique and had him freed (C. A. St. Beuve, *Nouvelles Lundis*, **2** (1864) p. 76).

   * Biot, Jean Baptiste (1774–1862). A pupil at the college of *Louis-le-grand* he entered the army in 1793, and then became a pupil at the *École Polytechnique* where he attracted the attention of Monge. He was one of the insurgents on 13 Vendémiaire, was captured and owed his release to Monge. He became Professor at the École Centrale at Beauvais in 1797. Through the influence of Laplace he was appointed Professor of Physics at the *Collège de France* in 1800 and a member of the first class of the Institut in 1803. In 1806 he visited Spain with Arago to complete the measure of the arc of meridian commenced by Lalande and Machais. In 1809 he was appointed Professor of Physical Astronomy at the Faculty of Sciences. He worked in many different branches of physics and is remembered by the law of Biot and Savart for the mechanical force produced by a magnetic field on an element of current carrying wire. But his most important work was on the shape of the earth as described in his *Memoire sur la figure de la terre* (1827), and on the rotation of the plane of polarization of light by various liquids and crystals. This latter work was the origin both of polarimetry as an analytical method and of Pasteur's pioneering researches in stereochemistry. Having prepared himself for the position of perpetual secretary at the *Académie des Sciences* by literary productions such as his *Essai sur l'Histoire Générale des*

Sciences pendant la Révolution and his *Éloge de Montaigne* he was bitterly disappointed to be passed over twice, first for Fourier (1822) and then for Arago (1830). He was elected to the *Académie des Inscriptions et Belles Lettres* in 1841, and to the *Académie Française* in 1856.

The explanations of Biot's relative lack of success as a scientist in spite of the enormous quantity of work he undertook is perhaps best explained by C. A. St. Beuve who in an interesting essay on Biot (*Nouvelles Lundis*, vol. 2, 1864, pp. 70–109) relates that the 'competent' persons from whom he demanded an opinion of Biot as a scientist were generally in accord that he was 'endowed to the highest degree with all the qualities of curiosity, finesse, penetration, precision, ingenious analysis, method, clarity, in short with all the essential and secondary qualities, bar one, genius, in the sense of originality and invention' (Op. cit., p. 71), (*Bio. Gen.*, *Gde. Encycl.*).

11. Taken by him at the Collège de France. See n. 7 above.
12. He is referring to the École Normale.
13. For an interesting account of the history of this rule, and of the new proof given of it by Fourier in his lectures at the École Polytechnique, see Grattan-Guinness (3), pp. 8–12.
14. But it seems to have passed into the canon by other means.
15. The famous Écoles Centrales of the Directory formed part of a new system of primary and secondary education—the first to take the place of the system of the *ancien régime* which had largely been destroyed by the Revolution—laid down in the decree of 26 October 1795. The thinkers responsible for this new system—later contemptuously dubbed the *idéologues* by Napoleon—included Ginguené, Daunou, Volney, François de Neufchâtel, Destutt de Tracy, Cabanis, Lakanal, and Garat, based their educational beliefs on the sensualism of the Abbé Condillac, especially in the interpretation of Cabanis and de Tracy, the two foremost theorists of the movement. The Écoles Centrales marked a genuine educational innovation of great value, and although these schools largely failed to achieve the aims of their founders, and were soon to be abolished (1802 onwards) nevertheless they exercised an enduring influence both inside and outside France. The full course of study in the Écoles Centrales was to extend over six years divided into three cycles of two years each. The first cycle was devoted to Latin, design, and natural history. Through an enlightened method of teaching pupils were supposed to acquire in two years a knowledge of Latin previously only attained in five or six. The language was taught not for its own sake, nor out of respect for ancient traditions, but because of its utility in medicine and law, and for the training of the mind it provided. Design provided a training of the pupils' observational powers, and could contribute equally either to the prosperity of the future artisan or to the enjoyment of the man of leisure. Natural history was of particular importance as it provided a prototype of sound scientific method based on observations. It also brought the pupil into contact with nature, and this among other things might lead to a much-needed improvement in French agricultural practice which was in many respects backward compared with that in other countries, especially in England. The second cycle was devoted entirely to mathematics and the physical sciences, mathematics being studied for two years and physics and chemistry for one year each. Apart from their obvious utility, these studies could train the mind and rid it of the errors and superstitions of a priest-ridden gothic outlook. The final cycle was intended (by

the *idéologues*) as the crown of the whole course of education provided by the Écoles Centrales. It was made up of *grammaire générale*, consisting of ideology—that of the *idéologues*—and the principles of language and logic with especial reference to the views of Condillac and his *idéologue* interpreters Cabanis and de Tracy. There were also to be courses in legislation, history—to be taught from a strictly unbiased, international point of view—and *belles-lettres*. The last course was peripheral to the other studies, and was intended to give students polish rather than a deep knowledge of literature.

The decree of October 1795 envisaged one École Centrale in every department, the towns chosen in almost every case having a building of a former college available. The departmental administrations were to be responsible for the organization of the schools. This was probably a mistake, at any rate from the point of view of the inculcation of ideological views, since many of the administrators failed to follow the views of the *idéologues* closely enough. The performance of the Écoles Centrales from their foundation in 1795 until their dissolution under Napoleon in 1802 varied greatly both from department to department, and from subject to subject. Thus design and mathematics seem to have been the most popular courses—pupils had freedom of choice—followed by natural history and physical sciences, though the popularity of the latter subject depended largely on the availability of apparatus. One general factor which militated greatly against the success of the schools was the universally low level of primary education. Much of the time of the professors in the Écoles was thus taken up with elementary teaching instead of the more advanced courses envisaged by the *idéologues*. Needless to say, the course of *grammaire générale* was the least popular of all the courses (Barnard; Fayet; Williams).

16. In fact the École Normale was closed down without examinations.

VIII

Fourier to Bergoeing, June 1795

Paris, 24 Priarial, Third
year of the Republic.

To Citizen Bergoeing,[1] Representative of the People.

Citizen; I was arrested several days ago thanks to the civil committee of the Section of Social Contract; you will know the reasons for this detention by taking cognizance of the order of the representative of the people Mailhe[2] and of the printed letter[3] of the public prosecutor of the commune of Auxerre. From these papers it follows that I have been included in the number of citizens to be disarmed in the commune of Auxerre; my personal defence had not been heard when this order was taken with respect to me. I was then a pupil at the École Normale. Independently of the duties which this position prescribed me, the Committee of Public Instruction had imposed on me a more special duty by instructing me to give a public course of mathematics in the Collège de France. I was not able to visit Auxerre[4] to explain the grounds of my justification. They were not known to the representative of the people, and I was informed by letters from my relations that I had been included among those to be disarmed before I knew the matter was being considered at Auxerre. I had no kind of notification of the order concerning me. I had two brothers at Auxerre neither of whom received this document. The citizen Mailhe made a new order on 11 Prairial carrying the pain of detention against those who resisted the disarmament pronounced against them. A statement of this order was sent to each of the persons concerned. I was not at Auxerre and the municipality of Auxerre knew that I was living temporarily in Paris with the intention of studying medicine.[5] Neither myself nor any of my relations received this new order. Nevertheless, I wrote to the municipality that *I intended to obey without delay the order of the representative of the people directing my disarmament, and in spite of the fact that I only had an indirect knowledge of the order I would hasten to conform to it. I declared that I was neither the owner nor the holder of any arms, and that if I had had any, I would instantly have put them in safe custody, requesting this declaration should be regarded as equivalent to the surrender of my arms.*[6] Moreover no one contested the truth of my declaration and all those who were acquainted with me knew well that I was never armed. This letter was dated 12 Prairial and I protested that I had no knowledge of the later order of the citizen Mailhe. In any case my country was distant forty-two leagues from Paris. Fearing that this declaration would not appear adequate to the municipality of Auxerre, I invited it in a second letter to indicate the constituted authority before which it wished me to present myself to effect my disarmament in a regular manner, in case my (original) declaration was not approved. All this sufficiently proves, citizen, that I had no intention of avoiding the measure directed against me, and that consequently I did not come under the order of the representative of the people dated 11 Prairial which had in any case been addressed neither to myself nor my family. It seems to me that in accordance with natural justice I should have been interrogated before suffering detention. When I was arrested I was assured that I was only to be conducted to the Committee of General Security to give an account of my conduct. I was placed provisionally in the prison Des Orties and the principal object of this petition is to ensure that you should be so good as to proceed yourself, or be present at my interrogation.

As to the charge of terrorism, I am unable here to advance all the reasons which will convince you that these charges are unfounded. I shall only insist on the incontestable facts that no-one in the commune of Auxerre was condemned to death or judged by the Revolutionary Tribunal at Paris; that no revolutionary tax was established of any kind whatsoever, that the property of those detained was never confiscated, that no cultivator, artisan, or merchant was arrested, that in what concerns me personally I believe that I introduced into my conduct and my opinions a moderation which I did not find in my adversaries, that far from having shared the revolutionary madness of many men I regarded it with horror and blamed it publicly; that I have experienced terror more than I have inspired it, as I was the victim of it precisely on the same date a year ago, that I was arrested and even condemned to death,[7] delivered by the unanimous demands of the assembled sections, the same which abandoned me or pursued me today, arrested again so that I owed to 9 Thermidor both life and liberty, so that there is no one of my compatriots who has known more danger than I.

The representative of the people Guillemardet[8] sent to this department after 9 Thermidor was familiar with the general facts which I have related to you; the citizen Mailhe did not think it proper to order any arrest, and there is not any really just and lawful reason for my arrest. I confidently address my complaints to you and I beg you to excuse the disorder and length of this letter. I have scarcely enough freedom of mind left to justify myself; your humanity will make up for that.

Fourier, Joseph

Notes

1. Bergoeing, François (1755–1820). A surgeon by profession, he was elected to the Convention by the Department of the Gironde and sat and voted on the right with the Girondins. At the trial of Louis XVI he voted for a reprieve and imprisonment and appeal to the people. On 21 May 1793 he was named one of the committee of twelve empowered to investigate the commune of Paris and the plots against public order and liberty. On 2 June he was ordered to be arrested. He fled to Caen, took part in the insurrection there, and was declared a traitor to the country on 28 July. But he escaped and reappeared at the Convention with the remnants of the Gironde in Year III, and was one of the most ardent post-thermidorians. On the day of 1 Prairial he was one of those who marched to the deliverance of the Convention. On 8 Prairial he denounced Panis and contributed to his arrest. Later he entered the Committee of General Security. He was a member of the Council of 500 where he opposed the royalist reaction. A friend of Barras, he resigned on 19 Brumaire. He served Murat in Naples under the empire and returned to Paris in 1815 where he lived in obscurity till his death (*Bio. Gen.*; *Gde. Encycl.*).
2. Mailhe, J. B. (1754–1839). A lawyer by profession, he was a deputy to the Legislative Assembly. On 10 August 1792 he was able to save the lives of a large number of royal guards. In the Convention he presented the report on the question of the judgement of the King and came out in favour of a trial. He voted for the death of the King, but for a reprieve. He lay low during the Terror but after 9 Thermidor was one of the most fervent accusers of the ex-terrorist Carrier. As a member of the Council of 500 he demanded in March 1796 the dissolution of all Popular Societies. He was included under the proscription of 19 Fructidor Year 5 (5 September 1797) but was recalled by the Consuls and nominated Secretary General of the Department of Hautes-Pyrénées. On his return to Paris he gained a great reputation as a lawyer at the court of appeal and the council of state. He was exiled as a regicide by the law of 12 January 1816 but returned to France after the July revolution (*Bio. Gen.*).
3. Unfortunately not in the file with the other documents of the case in the *Archives Nationales*.
4. This should be compared with the apparent willingness to visit Auxerre expressed in Fourier's letter of 28 Ventôse Year III to Bonard where he also mentions his position at the Collège de France.
5. This is the only indication we have that Fourier ever thought of forsaking mathematics for medicine.
6. Italics Fourier's.
7. Fourier must be referring here to his imprisonment in Auxerre in Messidor Year II. But his condemnation to death is difficult to accept as he would need first to have been transferred before the revolutionary Tribunal at Paris, and there is no trace of this.
8. Guillemardet, Ferdinand Pierre (1765–1808). When the Revolution broke out he was a Doctor at Autun. He was elected to the Convention where he voted for the death of the King. On his motion the Convention had a medal struck to commemorate 10 August. He was sent on a mission to the departments of Seine and Marne, Yonne and Nièvre in December 1794. At Nevers he ordered the arrest of members of the revolutionary committee who had been responsible for various illegal acts. He was appointed Ambassador to Spain in 1798 but was recalled by Napoleon because of his inactivity and was appointed Prefect of Charente-Inférieure. In 1806 he was transferred to Allier where he behaved unwisely dying two years later of mental illness (*Bio. Gen.*).

IX

Fourier to Villetard, June/July 1795

To Citizen Villetard[1] Representative of the People

Citizen,

You have wished me to set forth the grounds of a justification rendered necessary by unexpected calumnies. The notes which I address to you on this subject will contain facts known publicly or privately which I claim to be true. The exactitude and the veracity of this report will contrast with the vague denunciations of certain obscure adversaries who are trying to turn public opinion against me.

You know what my profession was at the time of the Revolution. Devoted to the study of the exact sciences from childhood with an ardour greater than would seem called for in such a calling, I achieved that success in it which steady application hardly ever fails to produce. At 16½ years I was appointed Professor of Mathematics at the military school of Auxerre; the memoirs[2] which I wrote four years later and which I read at the Paris Académie des Sciences sufficiently prove my exclusive taste for such researches. I recall these facts as at least plausible proof of the regularity of my principles; and, in fact, which one of my compatriots would dare to question these principles, have I not passed all the days of my youth in the strictest propriety, in the calm of passions which are even excusable,[3] in the obscurity and silence of the study?

The first events of the Revolution did not change my way of life. Because of my age I was still unable to speak in public; and impaired by night studies my health scarcely sufficed for the work my position required of me.

From another point of view I will admit frankly that I regarded these events as the customary disturbances of a state in which a new usurper tends to pluck the sceptre from his predecessor. History will say to what extent this opinion was justified. Republican principles still belonged to an abstract theory.[4] It was not always possible to profess them openly. As the natural ideas of equality developed it was possible to conceive the sublime hope of establishing among us a free government exempt from kings and priests, and to free from this double yoke the long-usurped soil of Europe. I readily became enamoured of this cause, in my opinion the greatest and the most beautiful which any nation has ever undertaken.

The public duties which I carried out did not allow me either to wish for or to undertake any others. The law of 21 March 1793, old style, having established sectional committees for receiving the declarations of strangers and travellers, I was afterwards chosen in the General Assembly as a member, something which nobody then regarded as a public position. However the duties of these committees were successively modified, and various laws entrusted them with a universal surveillance which soon degenerated into very extensive powers since the law of 17 September ordered them to proceed to the arrest of suspects. I had no doubt that this measure was legitimate, and one could cite the illustrious Montesquieu[5] in support of this opinion. However I considered myself much less fitted than many others to enforce this law. I offered, even sent in, my formal resignation of the commission which had been given me—the original of my letter is in the Public Archives[6]—and I ended by stating *that if any of my co-citizens were opposed to my resignation being accepted, I declared that I was determined to persist in it, that any attempt to change my mind would be useless and embarrassing . . . that I would not be less zealous in defence of the liberty of the people.*[7]

This move produced an effect opposite to what I had intended. In the reply sent to me I was reminded of a law which forbade any official from abandoning his post, and my resignation was rejected. At the same time other persons openly accused me of abandoning my colleagues at a moment when my help was about to become most useful to them. I was reproached with the feebleness of my conduct, and some even seemed to doubt the purity of my intentions.

I remained a member of the committee of surveillance of the commune of Auxerre up to the time not long time past when a choice was allowed between that position and that of school teacher.[8] That was the source of all the persecutions which I have undergone.

In the month of Frimaire last when I was Professor of Mathematics at the College of Auxerre, and unbeknown to me, the administrators of a neighbouring district nominated me as a pupil of the École Normale. I did not wish to accept without the authorization of the constituted bodies of the commune of Auxerre. I informed the district administration of this nomination, they confirmed it, and in the order addressed to me included a fair testimonial of my civisme and principles. These administrators are today still public officials. The Committee of Public Instruction and the professors of the École Normale having entrusted me with giving mathematical lessons to the pupils at the Collège de France, I was not, as I wished, able to visit the commune of Auxerre to reply to my denunciators.[9] They realized all the advantage my absence gave them and employed it to good effect. They had tried unsuccessfully to make use of the authority of the citizen Guillemardet[10]—then on mission in this department—against me. When the representation of the people Mailhe[11] succeeded him they demanded my disarmament and obtained it. This measure was not taken against any one of my co-citizens without him being heard, but in my case this was not possible. They managed to inspire the representative of the people with the most fearful and even the most improbable prejudices.

To the denunciation of terrorism which is habitual with them, and to the reproach of having been a member of the Committee of Surveillance, I reply with the following declarations.

I was entrusted by their own votes with a surveillance determined by the law. I received this position without soliciting[12] it, I continued in it without the power of withdrawing from it, and I exercised it without passion.

I had no grounds for hatred, I had up to that time formed so few links with other people that I had no enemies. I respected the power which was given to me; I said and repeated a hundred times that we would have to render an account of it one day.

Let my opponents recall any act in which I participated and I will cite the article of law on which it was founded. As regards the internal régime of the house of internment, I argued that everything not expressly forbidden by the law should be allowed.

Over a long period the committee was advised to sequester the goods of those detained. I constantly opposed it; my opinion in this matter was always that of my colleagues, and they all constantly rejected whatever seemed to them to exceed the limits of the law.

No revolutionary tax was imposed of any kind whatsoever, and there were never any domiciliary visits.[13] The National Convention never had any need to free any tradesman, artisan, or cultivator. No family had to grieve at this time for a father or a relation. The Revolution cost the life of several of our co-citizens at this time, but it was on the frontiers of the state that they lost their lives while fighting the enemies of the freedom of the state. If there were dangers, it was our kith and kin who ran them, it was my two brothers of whom the youngest fought from the beginning of the first campaign, and who for the last two years have both maintained the most alarming silence.

There remain, therefore, those citizens[14] who being nobles or priests or relations of *émigrés* found themselves included under the law of 17 September, and who experienced a temporary detention when they showed themselves declared enemies of the Revolution. They accuse me of not having been opposed to their arrest and will never pardon me for having signed the warrants for their arrests. They pretended to believe that I could have released them, and wanted me to make this use of the trust which had been placed in me.

Being unable to accuse us of abusing our powers they reproach us with excessive rigour, but far from having merited this insult I believe that I have accorded to humanity, friendship, generosity even, all that was allowed by the letter of the law and the rigour of the times.

I could cite citizens that I defended against injust denunciations, those that I protected by secret warning,[15] those that owed me their release from prison. May I not recall also, since my adversaries stop at nothing, that I was in the habit of defending innocence, feebleness, and error in the courts. I never considered the profession, fortune, or the opinion of those accused. I usually defended the poor, but some nobles, and even prisoners charged with criminal offences, have asked me to speak in their defence.

Of all those who devoted themselves to these affairs I was the only one who drew no profit from them, and I accepted from those that I defended no recompense of any kind whatsoever. I am ashamed to make a show of this disinterestedness, it is not for me to recall it, but I am reduced to proving that I am not a monster of immorality and inhumanity.

The only *fact* that they cite in support of their denunciations is the reproach of my having drawn up inflammatory addresses. Here is my reply to this charge, the only one which is not devoid of all plausibility. I pass over the inconvenience which would arise through regarding as punishable today opinions advanced some two years ago, but I insist that my opponents produce a writing of mine in which humanity is not respected; that they take care not only to recall isolated passages but that they cite the whole writing. They have had sufficiently little discernment to attribute to me addresses in which I took no part instead of those which I did in fact compose. If I were to be judged at the tribunal of Coblenz[16] I certainly would not be acquitted, but I have nothing to fear if one has the honesty not to transform into crimes errors and faulty opinions, and even exaggerations, which the distance of the places, the actual sequences of events or a feeling of peril may have caused. I have never provoked or approved any of the revolutionary excesses or violent measures which have dishonoured the popular cause in France. However, if one wishes to try me on that score the documents are extant, they are printed in the Bulletin of the Convention, for I can assert that there was not one of the addresses which I drew up either before or after 9 Thermidor which did not receive honourable mention, a circumstance which I know is little calculated to justify me in the eyes of my accusers.

Citizen, you know as well as I do the persecutions which I experienced two months before the fall of the government brought down by 9 Thermidor. You know that the defence—perhaps imprudent but at least disinterested—which I dared to make of three paterfamilies[17] was the reason for my disgrace; proceeded against on the basis of the report of Barère, I was soon arrested at Auxerre by two emissaries,[18] one of whom was outlawed on 10 Thermidor. You will remember with what ardour and with what a universal agreement of witnesses my release was demanded by my fellow citizens. Released at first, I was arrested again three days later on the same grounds and detained until 24 Thermidor. Ultimately I experienced every degree of persecution and misfortune, none of my adversaries have run more dangers, and I am the only one of our compatriots who was condemned to death.[19] Nevertheless, they have the injustice to forget the terror which I experienced only to speak endlessly of that which I am said to have inspired.

They formed a plot to get me out of public teaching. All the pupils whom I taught in the school of Auxerre are today employed in civil or military engineering, and yet they want to say that I am incapable of public teaching. There is no sophism which has not been invented to that end in the sectional assemblies, they repeat there continually that as a member of the Popular Society of Auxerre I was a Jacobin (that is to say an immoral terrorist), that there is the most extreme danger in entrusting me with teaching mathematics and physics. I reply to this that my morals are beyond reproach and that there is neither a liar nor a fool who could say otherwise, that it is not a matter of terror here but of truth, that being a professor of mathematics I do not bring up children but instruct those who want to better themselves, that they themselves are in bad faith, that if they had sons whom they destined for employment of this kind they asked me to look after their education.

I add finally that to exclude me from a school of mathematics is to take away from me an entirely legitimate possession[20] which I have acquired by my work and which I retain by cultivating it daily.

At the time when attempts were made in Auxerre to perpetrate this useless and absurd injustice, I was put in charge of public classes[21] in Paris under the auspices of the government; it was then that they broke out in denunciations which they addressed to the Committees of General Security and of Public Instruction. They did not have the effect they desired since they bore the evident mark of persecution. Soon afterwards, without having ever solicited it, I was called to the Central School of Public Works.[22] This circumstance infuriated them anew and I never managed to disarm this implacable coalition of ignorance, hate, and envy. I finally declared that I was ready to renounce all the positions given me by the government, and trying the line of giving way for a time before oppression I gave up a right which I had acquired by study and vigils. Once again they refused me the shade of tranquillity which I requested. My disarmament had been notified neither to me or to any of my relations, although this was done in the case of all the others. In spite of my repeated declarations they treated me as if I wished to escape and their pursuits affected my arrest. What follows is known to you.

Citizen; there are the facts which I wish to draw to your attention. You will judge whether it is I or my adversaries who are terrorists and persecutors. For my part I accuse them of having violated in my regard all the rules of natural justice, of being ignorant and evil, of profaning the words humanity and justice in invoking them, just as tyranny was organized in the name of liberty. Finally, of having given themselves up to a boundless revolutionary fury which ought to cover them with disgrace and scorn.

Fourier, Joseph

Notes

1. Villetard, Edmé Pierre Alexandre (1755–1824). A wine merchant in his native town of Auxerre, he was elected a substitute deputy to the National Convention for Yonne. On 25 January 1793 he was called to replace the assassinated Michel le Pelletier. He became a deputy member of the Military Committee of the Convention on 18 Fructidor Year II and was maintained in this position in Year III. He was secretary of the Convention from 16 Vendémiaire Year IV to the end of the session. In 1799 he became a member of the senate and he was created a Count of the Empire in 1808. He retired on the fall of Napoleon and lived in private thereafter. According to local tradition Villetard was a very cautious man who had every intention of dying in his own bed unlike his unfortunate colleagues Le Pelletier, Maure, Boileau, and Bourbotte of whom the first was assassinated, the second committed suicide, and the remaining two were guillotined.
2. He would be referring to the memoir on numerical equations read to the Académie des Sciences in December 1789. See reference to this above in Letter II, n. 6.
3. 'Dans le calme des passions même excusables.' The sense being that the 'strict propriety' of his life even extended to his passions, which being directed towards study were themselves not subject to blame.
4. That is before they came into the open following the flight of the King to Varennes on 20 June 1791. See above, chapter 2, n. 2.
5. Citation unknown.
6. This letter has disappeared.
7. Italics Fourier's.
8. This is confirmed by *Arch. Yon.* Reg. L. 557^1.
9. This is to be compared with a similar excuse in Letter VIII above (to Bergoeing) as opposed to the possibility of visiting Auxerre mentioned in Letter VII (to Bonard).
10. See Letter VIII above, n. 8.
11. Ibid., n. 2.
12. In one of his applications for a retirement pension following his return to Paris in 1815 Fourier made exactly the same apologia regarding his appointment by Napoleon as Prefect of the Rhône. He makes the same claim again in the penultimate paragraph of the present letter in regard to his appointment to the École Centrale des Travaux Publics (later École Polytechnique).

13. As opposed, for example, to those carried out in Orléans in August 1793 by the forty commissioners appointed to investigate the hoarding of grain by merchants. See Lefebvre (2), vol. 2, p. 134.
14. Such as the François Leblanc part of whose letter from prison of 11 Germinal Year II describing his interrogation by Fourier and Maure is reproduced above in chapter 2, p. 41.
15. Such as the citizen of Tonnerre he saved from arrest by an agent of the Committee of Public Safety. See account of Cousin's story above in chapter 2, p. 40.
16. Coblentz was the chief *émigré* centre until its occupation by French republican forces in 1794.
17. For the identification of these three paterfamilias see above, chapter 2, p. 34.
18. It is tempting to assume that one of these emissaries was Robespierre's agent Demaillot. See above, chapter 2, p. 43.
19. The reasons why it is difficult to accept this statement at its face value have already been given above in chapter 2, p. 44.
20. The inviolability of private property continued to be observed, at least in principle, throughout the most radical phases of the Revolution.
21. He is referring to his position as one of the *maîtres des conférences* in mathematics at the École Normale, Fourier's class being held in the Collège de France. See Letter VII above.
22. Later École Polytechnique.

X

Fourier to Bonard, October 1795

Paris, 30 Vendémiaire, Year IV

My friend, I reply in great haste to the letter you were good enough to write to me. I know you have been appointed to examine candidates for the École Polytechnique although I do not believe I have had anything to do with this.

You ask me for information that I am hardly in a position to give you; it seems to me the text of your commission should sufficiently inform you what you are to do at this juncture. The marks arising from your examination are passed on to a jury composed of several distinguished scholars who compare them, in so far as that is possible, with those sent by the other examiners, and they choose the candidates whom it seems right to them to place higher on the list. The members of the jury are Laplace,[1] Cousin,[2] Legendre,[3] and Lacroix,[4] unless I am mistaken over the last name. You can see all the imperfections of this examination procedure. Whatever uniformity one attempts to enforce in the marks it is obvious that one can obtain nothing satisfactory in this way. Once chosen in this way the candidates undergo no further examination. At least there has been none up to the moment. I do not believe it will be different this year. If they had to be interrogated again on their arrival at the school, I would probably be the only one detailed to do it.[5] I think that the members of the jury will be all the more satisfied with the individual examiner the more they appear to have conformed to the method prescribed to them. In my own mind, what I most desire is to see young people entering the school who have outstanding talents regardless of how much they have actually been taught. What they may have learnt matters little to me if they do not have a marked taste for mathematics and extraordinary aptitudes, accompanying these qualities with aversion, or at least indifference, to the frivolities of which Paris offers so many opportunities. The worst of all faults would be nonchalance. I have unfortunately noticed it too often in the young people who come from Auxerre. This is also the viewpoint of the professors of the school who, moreover, do not contribute in any way to the choice of candidates. For that it has been considered necessary to consult savants outside the establishment.[6]

I am assured that the number of candidates presenting themselves is less than it has been in other years.[7] On Roux's[8] evidence it seems to me that the two young men of whom you spoke to me are in a position to be admitted.

I shall fortunately have the opportunity to write to you again and I shall [then] enter into the details which lack of time obliges me to omit. Please do not neglect this correspondence; you must not doubt the pleasure you will give me. I very much approve of Madame Bonard's intention to leave Saint-Georges which is not perhaps a very healthy place to live in. Your post, which up to the moment has availed you nothing, cannot fail to become very favourable, and it provides a security which makes it preferable to all others. I have it on good authority that the state system of education may be modified in many respects, but not as regards mathematics. Remember me to Madame Bonard and embrace for me all your little family, and especially our little René. Write to me sometimes and be assured that I shall never forget our long standing friendship of which I offer you the most sincere assurances.

Your friend,
Fourier

Notes

1. See above, Letter VI, n. 10.
2. See above, Letter VI, n. 4.
3. See above, Letter III, n. 4.
4. Lacroix, Sylvestre François (1765–1843). The son of poor parents, he obtained the position of Professor of Mathematics at the school of *gardes de marine* at Rochefort at the age of seventeen through the influence of Monge. He was professor of the École Normale and later at the École Centrale des Quatre Nations. In 1799 he entered the Institut and took the chair of analysis at the École Polytechnique which he left in 1815 for the Sorbonne and the Collège de France where he succeeded his master Mauduit. Lacroix made important contributions to the teaching of mathematics through his textbooks including his *Traité de Calcul différentiel et intégral* (3 vols, 1797–1800) and the different volumes of his *Cours de Mathématiques* (10 vols, 1797–9). Both of these ran through many editions, and in English translation played an important part in the transmission of continental methods in mathematics and theoretical physics to the British Isles (*Bio. Gen.; Gde. Encycl.*).
5. Judging by Fourier's letter to Villetard (see above, Letter IX, n. 22) Fourier had originally been appointed to a position in the École Centrale des Travaux Publics. This must have been in 1795 before his second imprisonment. Fourcy (p. 94) relates that Fourier was appointed to the '*police des études*' in 1796, by which time he was already responsible for 'a part of the analysis course' and that in 1797 (probably in June) he was continued as assistant to the mathematics teachers, the three positions in '*police des études*' having been suppressed.
6. Referring to the selection 'jury' for entry to the school whose members he had already listed.
7. There had, in fact, only been one previous year.
8. See above, Letter IV, n. 2.

XI

Fourier to Bonard, November 1797

Paris, 20 Brumaire [Year VI]

I have just, my friend, left a person from Avallon who is very interested in a young man of that district who hopes to enter the École Polytechnique. Villetard,[1] to whom he was recommended as well, has asked my advice on the matter.

I replied that there was only one door by which to enter this school, and that it was neither his business nor mine to introduce the young man there other than by way of examination.

Citizen Boileau, the brother of a man[2] whose patriotism and misfortune had rendered him somewhat celebrated, has assured me that this young man had entirely satisfied you, and that he had devoted himself to the study of mathematics with an enthusiasm which promises great talent. You will doubtless easily have recognized the aptitudes shown by this boy, and in that case I very much wish him to enter the school.

It will be very difficult to be admitted this year. Things have turned out precisely opposite to what I had been told. The number of candidates at Paris is considerable, the examiners have told me that they are much more satisfied, and that there is no comparison between this year and the preceding ones; they kindly attribute this change in part to my lectures[3] which have become widely known.

On the other hand, the number of pupils will be greatly reduced by the government,[4] and many will be forced to leave the school. These circumstances will make entry very difficult, so that it will be necessary to give very high marks to young people whose entry one desires since they will be regarded, in effect, as capable of making great progress in mathematics.

Having foreseen these difficulties, and knowing that the members of the election jury greatly distrust the abilities of several departmental examiners who are unknown to them, I have given them advance notice of the candidates they might receive from Auxerre, and Laplace[5] in particular, whose opinion carries most weight, agrees with me that special attention should be paid to these candidates since their recommendations originate from a just and very learned man.

I have seen no other means than this of responding to the wish of Villetard and the citizens of Avallon, while at the same time bearing witness to the truth.

Roux[6] will also have spoken to you of a young pupil[7] of citizen Billy, professor at Fontainebleau. All those that he has sent us have had adequate ability and he himself is an entirely adequate teacher.

I thought, my friend, that you would be pleased to receive this information, and that gives me the opportunity to reiterate to you and to your wife and family the assurance of the sincere attachment with which I am

Your friend
signed: Fourier.

Embrace for me Madame Bonard and little René.[8] My regards to all your colleagues.

Notes

1. See above, Letter IX, n. 1.
2. Boileau, Jacques (1752–93). A judge of the peace, he was elected to the Convention for the district of Avallon in the department of Yonne. He demanded a decree of accusation against Marat on 25 September 1792. He voted for the immediate execution of the King without stay or appeal to the people. Thereafter he voted with the Gironde and was elected a member of the ill-fated commission of twelve on 21 May 1793. He was arrested on 2 June. He retracted before the Revolutionary Tribunal: 'I have searched for the truth. I have found it among the Jacobins and I am now a Jacobin.' Nevertheless he was guillotined with the Girondin leaders on 31 October 1793. Boileau was succeeded at the Convention by his brother (*Bio. Gen.; Gde. Encycl.*).
3. For details of the extant part of these see Grattan-Guinness (3), pp. 6–7.
4. The successive numbers of entrants in the years 1794, 1795, 1796, 1797 were 396, 355, 361, and 266 respectively. The present letter can therefore confidently be dated as 20 Brumaire Year VI, i.e. 10 November 1797. The reduction in numbers was due to the financial situation.
5. See above, Letter VI, n. 10.
6. See above, Letter IV, n. 2.
7. Poisson, S. D. (1781–1840). Poisson's mathematical powers were first awakened through reading the journal of the École Polytechnique which was sent to his father as leader of the local commune. In 1798 he headed the list at the École Polytechnique, where his genius for mathematics was quickly recognized by J. L Lagrange whose course in analysis he attended. In 1800 he was appointed demonstrator at the École, and in 1802 became assistant to Fourier whose Chair he assumed when the latter became Prefect of Isère. In 1808 he was appointed astronomer at the Bureau des Longitudes and in 1812 became a member of the Académie des Sciences. He was appointed mathematician at the Bureau des Longitudes in succession to Laplace in 1827.

   In his fundamental memoir of 1812 Poisson adopted a two-fluid theory of electricity in which like fluids repelled and unlike attracted according to the inverse square law. Taking over mathematical results from the theory of gravitational attraction, including Lagrange's potential function, Poisson showed that this function would be constant over the surface of an insulated conductor. Acting on a suggestion of Laplace, he gave an ingenious proof of the formula for the force at the surface of a charged conductor. He also gave solutions to various problems, including the calculation of the surface densities of charge for two spherical conductors placed at any distance apart, his theoretical results being in excellent agreement with those already obtained experimentally by Coulomb. In an equally fundamental paper of 1824 Poisson gave a wonderfully complete theory of magnetism based on Coulomb's two-fluid model deriving a general expression for the magnetic potential at any point as the sum of two integrals due to volume and surface distributions of magnetism respectively. He also investigated the problem of induced magnetism. Apart from his work in electricity and magnetism, Poisson made important contributions to the calculus of variations, differential geometry, and to probability theory in which he is remembered by the distribution bearing his name. He contributed also to the theory of elasticity in which field the ratio of lateral contraction to longitudinal extension is known as Poisson's ratio. He also contributed to the theories of capillarity, heat, and dispersion. In astronomy, he wrote many important memoirs especially that of 1833 on the movement of the moon (Arago (2)).

8. Joseph Antoine Réne Bonard, became chief medical officer of the military hospital in Calais, *chevalier* of the Legion of Honour, and retired as surgeon-major first class. He died at Calais in 1858 (Challe (2), p. 130, footnote 1). From Letter XII below it appears that Fourier had baptized him.

XII

Fourier to Bonard, November 1801

Toulon, 29 Brumaire, Year X

My Dear Bonard,

I have just at last completed my voyage from Egypt which leaves me with nothing but the most agreeable memories.[1] I entered the port of Toulon a few days ago and I am in as good health as I could hope for after such prolonged hardships. I hope that you will have retained your friendship[2] and that you will be glad to hear of my happy return to France; one could not return in more favourable circumstances. The study of the antiquities of Egypt and the positions that I filled in the civil government of the country in no way diverted me from the study of mathematics; up to the moment I have not actually published any of my researches. I shall not delay doing so, if, as I greatly desire, I am last fortunate enough to enjoy a substantial period of leisure in Paris, but it will be necessary for me to devote my first days to the publication of my work on the astronomical monuments[3] we have discovered in Upper Egypt. As it is possible that you have not yet been informed of these results I will tell you, merely to give you a general idea, that the ancient inhabitants of the region of Thebes represented the state of the sky as then observed by them in the sculptures decorating religious buildings, and that the arrangement of that ancient celestial sphere is very different from the one which we observe today, a change which is principally due to the precession of the equinoxes; the amount of this movement, and even the reason for it, are today perfectly known, so that one can determine the epoch which the Egyptians intended to represent. A host of additional circumstances, and the interpretation of a hieroglyphic emblem, confirm the deductions that can be drawn from these sculptures for arriving at the age of the monuments. One can thus fix the time when the Egyptian people cultivated astronomy and the arts, and place within their true limits chronological epochs which seemed destined to remain for ever unknown.

I shall not go into greater detail today, and I reserve your attention for another time.

Present my regards to Madame Bonard and embrace in my name all your charming family. But I retain an altogether special affection for that one of your children whom I baptized.[4] If M. Rosman[5] still lives in Auxerre express to him the token of my regards and unalterable attachment which reflection and age can only increase.

I should like also to be remembered to our common friends, Roux,[6] Professor of Physics and Mathematics, Mathon,[7] and Amé.[8] I do not know if citizens Defrance[9] and Balme[10] are still your colleagues; please greet them and their families on my behalf. I think I have not yet lost all the friends that I have had since childhood among your fellow citizens; truly I believe I have kept them all, to judge only by my own feelings; please, therefore, announce my arrival to those to whom this news would be neither indifferent nor disagreeable.

[If] you have time to write to me at Marseille, where I shall go without delay, I shall learn your news with the most lively satisfaction. Address your letters to Marseille, *poste restante*, to Citizen Fourier, ex-commissaire of the government in Egypt. I should like to be informed in some detail of the position in your part of the world more with respect to personalities than affairs with which I have less and less to do.

I request you specially to inform my relations of my safe return, and more particularly to assure my friendship to that one of my brothers[11] whom I saw in Paris; he might give you a letter which you could address to me at Marseille.

I renew the assurances of my attachment to you and I desire that you may always want to retain your friendship for me.

Notes

1. By the terms of capitulation the remaining French forces were transported from Egypt to Toulon in British ships. Fourier's voyage from Egypt to Toulon would therefore have been much more comfortable than it would have been in the brig *Oiseau* in which the scientific commission had originally attempted to escape from Alexandria.
2. Possibly implying that Fourier had not been in correspondence with Bonard during his stay in Egypt: the postal service between Egypt and France was understandably somewhat erratic.
3. Altogether six astronomical monuments were found during the Egyptian Campaign, all containing signs of the Zodiac, the most famous being in the temple of Dendérah in Upper Egypt. In all these monuments different signs of the Zodiac were found in the 'first' positions, and it was assumed that this was due to the precession of the equinoxes, the sign given 'first' being supposed to be that corresponding to the solstice at the time of the construction of the buildings in question. This gave very remote ages of the order of 5 to 6000 years for the construction of all the buildings. When the results were published they were welcomed by some, but others were alarmed by the apparent contradiction with the sacred writings. Fourier prudently rejected with some warmth rumours that he was in favour of such ancient datings. No reference to the estimated age of the buildings containing the Zodiacs was given in the first draft of his Introduction to the *Description of Egypt* of 1809, although the published edition of 1810 contained a short reference of a somewhat ambiguous nature. But in the *Description of Egypt* itself he dated two of the monuments to around 2000 B.C. Soon after, the whole question was shelved by order of

Napoleon as disturbing to religious sensibilities. When the circular Zodiac of Dendérah reached Paris in 1822 the controversy broke out anew. J. B. Biot fixed the epoch of this Zodiac at 717 B.C. though this was contested by Champollion-Figeac the younger. In September 1822 the reading of hieroglyphic inscriptions by the latter led to the realization that the temples of Esné and Dendérah—where two of the Zodiacs had been erected—had been completed at the time of the Roman occupation of Egypt. Fourier was somewhat taken aback at this refutation of his calculations. But if these Zodiacs were omitted then his general views on the great antiquity of Egyptian civilization were later confirmed by Champollion-Figeac the younger and others who pushed the limits back even further into the past (A. L. Champollion-Figeac (1), pp. 123–5; J. J. Champollion-Figeac, chapter 5).

4. The 'little René' referred to in the postscript to the preceding letter written some five years earlier.

5. Rosman, Henri Antoine, born at Hesdin (diocese of St. Omer) around 1742. He became a professor at Jumièges in 1761 and in 1775 was appointed prior of the Abbey St. Germain. In 1777 he became principal of the École Royale Militaire at Auxerre. He was removed by his order from both these positions in 1783—in spite of a storm of public interest—after a commission appointed in that year had found the school heavily in debt and the affairs of both the school and the abbey in an inextricable state of confusion. His successor was a certain Dom Joseph Philippe Rousseau, previously Professor of Humanities at Lyons. On the retirement (or transfer) of Rousseau in 1788 Rosman returned as prior of the abbey and director of the school. On the provisional suppression of the regular orders at the beginning of 1790 Rosman was confirmed as principal, and had evidently no scruples in taking the oath of allegiance to the State recognizing its authority on at least four occasions.

In April 1793 certain of the so-called professor–priests (including the vice-principal Laporte) were dismissed from the college on the demand of the local Popular (Jacobin) Society. Rosman continued as principal till the following June when he was replaced by Balme. After his dismissal he hid for a time in the district of St. Georges close to Auxerre but was later discovered and placed in detention. Rosman was evidently a man of spirit, for the communal records note that he received a grave warning that any further acts of insubordination towards the guardian of the house of detention would result in his transfer to prison.

He was released some time after 9 Thermidor, being reinstated as principal of the college on 14 Ventôse Year III. When the college was replaced by an École Centrale in the following year Rosman retired to St. Georges where he announced the setting up of a boarding school for some twelve or so pupils in the following terms: 'Rosman, former principal of the college of Auxerre, informs the public that in order to satisfy the demands of a number of parents he has just set up his *pensionnat* at St. Georges, in the former country house of the college. Those who wish to confide the education of their children to him should make application. There follows the programme of the courses.' He spent the rest of his life peacefully at St. Georges apart from a period around 1797 when he was denounced for certain supposedly anti-Republican actions. He seems to have had little difficulty in defending himself against these charges. He died at St. Georges on 26 April 1799 in his fifty-seventh year (*Arch. Yon.;* Cestre (2); Moiset).

6. See above, Letter IV, n. 2.

7. Mathon——. He was one of the professors of the College of Auxerre in Messidor 1793 following the dismissal of all the professor–priests including Dom Rosman. He was one of those whose departure from the college in February/March 1795 had led to its complete disorganization. But in July 1796 he returned to become economic-director of the new École Centrale which had replaced the college and where he became Professor of *Belles-lettres* in November 1798. He was a professor for a short time in the École Secondaire which replaced the École Centrale in 1804 but by 1805 had left to set up a private *pensionnat* (*Arch. Yon.*; Cestre (3)).

8. Amé, Gerard. Born at Beru near Rheims, 1759. Studied at the college of 'Good Children', at the University of Rheims where he acquired the degree of Master of Arts. He figured among the list of professors at the College of Auxerre on 6 August, 1793, and also on several other occasions before 9 Thermidor. He was a member along with Fourier and Bonard of the provisional revolutionary committee on 23 Fructidor Year II. Later he returned to teach being named as an *instituteur* of the new system of education in the Commune of Auxerre on 26 Brumaire Year III. For some reason or other Amé never taught at the École Centrale. In 1805 he was appointed Professor of the fifth and sixth classes in the new École Secondaire which replaced the École Centrale. He generously gave up one of these chairs in favour of the ex-director of the school Choin. In 1808 he became regent of the third class. He retired in 1817 and was awarded a pension by the State who thus evidently did not know about his revolutionary activities in 1794 (*Arch. Yon.*; Cestre (3)).

9. Defrance ——. He appears as one of the professors of the college of Auxerre in Messidor Year II after the dismissal of all the 'professor–priests' including Dom Rosman. He was still a professor in August 1793. He interceded with Gautherot for Fourier before the Committee of General Security at the time of the latter's first arrest in Messidor Year II and he was one of those who successfully argued for the reintegration of Fourier and Balme into the Popular Society of Auxerre in the winter of 1794/5. Shortly afterwards he left the college which became 'thoroughly disorganized' owing to his departure and that of Fourier, Balme, Roux, and Mathon (*Arch. Yon.*).

10. Balme, J. G. Born around 1764, died 1841. A tonsured clerk at the outbreak of the Revolution he is said (Moiset, pp. 22–8) to have embraced its principles with enthusiasm. He does not appear on Dom Rosman's list of professors at the École Royale Militaire in 1790. Having acted for a time as secretary to Nicolas Maure, one of the representatives of Yonne at the Convention, he returned to Auxerre where he was elected a member of the General Council of Yonne. In June 1793 he was sent into the district of St. Florentin to recruit for the war against the Vendée. The same month he was appointed principal of the college at Auxerre in succession to Rosman. At the time of his appointment as principal the college at Auxerre was still a military college though naturally no longer a royal one. This explains the following letter of 22 June 1798 from the Minister of War Bouchotte to Maure:

> I have been informed, citizen, of the dismissal of principal Rosman, and of the choice of citizen Balme to replace him . . . The interest which you take in citizen Balme justifies his appointment in my eyes even more, and I am persuaded in advance of the good which he will do in this place.

Maure evidently passed on this letter to Balme as appears from the following postscript:

> I salute and embrace my friend Balme but he will have to believe in my good wishes, because I have not the time to express them to him in a long discourse.

Balme was one of the six commissioners sent to collect horses by Ichon's order of 23 Vendémiaire Year II. Unlike Fourier he does not appear to have been a member of the revolutionary committee of Auxerre. After 9 Thermidor, he was one of those appointed on 26 Brumaire Year III to the new system of education in the commune of Auxerre. Like Fourier he was purged from the Popular Society of Auxerre at the time of the first post-Thermidorian reaction, but was 're-integrated' (once again with Fourier) on 26 Nivôse Year III. He was appointed to the École Normale in company with Fourier, Roux, and Bonard. While in Paris he was condemned by the commune of Auxerre for his part in the Terror, but there is no trace of his having been arrested in Paris so that he may possibly have returned to Auxerre in time to comply with the disarmament order issued against him as a former Jacobin. In any case he was 're-armed' in company with Fourier, Bonard, and Maure Junior on 13 Fructidor Year III. Thereafter he played an increasingly important part in the local administration. In Year IV he became commissioner of the executive directory of the department at Vermenton, administrator of the department in Year VI, and vice-president in Year VIII. Under the Empire he was a judge of the peace at Avallon. After the Restoration he founded a '*pensionnat*' at Auxerre.

11. Probably the brother Jean Baptiste who wrote to the Committee of General Security at the time of Fourier's second imprisonment. See above, chapter 3, p. 56.

XIII

Fourier to Bonard, November 1802

Grenoble 4 Brumaire, Year XI

The Prefect of the Department of Isère

Will you allow me, my dear Monsieur Bonard, to entrust you with several small tasks relating to my personal affairs?

I am writing to Paris to have transferred to Messrs. Bastide & Son, Mont-Blanc Street, Paris, the sum of 1000 francs which will be paid out to you by the post office director of the department of Isère. I have informed M. Sauvalle in advance that I am sending the money; he will indicate to you the small payments which you are to make to M. Amé[1] and my nephew.

Further, one of my brothers who is in the Army, and whom I wish to buy out, but who is at present at Auxerre on six months leave, is apparently in need of money; please pay him 100 francs and inform him that he is to tell me the sum required to obtain his discharge—I shall give him this if it does not exceed what I am able to afford. As soon as he has retired from the service I shall give him a small pension and inform him how I wish him to use it; it is also my intention that he remain at Auxerre.

If you would be good enough to look after his initial correspondence with me I would be very obliged to you, please ask him how easy he expects to find it to buy his discharge in his corps; M. Sauvalle can give you very precise details in this matter; moreover the brigade commander wrote to me some time ago, he is quite ready to assist him; my dear Bonard, please take some interest in this affair. I should also very much like you to give me news of your family; no one desires more than I that you should enjoy the happiness which you so much deserve. Embrace on my behalf all your family and continue to be my friend.

I am writing today to Paris; the money will arrive within eight days; you will receive a letter of advice from M. Lefort, an employee in Paris.

Fourier

Note

[1] See above, Letter XII, n. 8.

XIV

Fourier to Bonard, January 1804

To M. Bonard
Professor of Mathematics
École Centrale of the Department of Yonne

Grenoble 9 Pluviôse Year XII

My Dear M. Bonard,

If I were not myself guilty of the greatest carelessness in my personal correspondence I would reproach you with your silence. But I am not in a position to accuse anyone. Be so kind as to give me from time to time news of yourself, of your family, and of our old colleagues in public education. How are Mathon,[1] Millon,[2] and Roux,[3] and what are you working on yourself at present?

I think that it would not be very difficult to have one or two of your children placed in a lycée.[4] Could I be of help to you in that connection? I do not know the names of the inspectors of studies in your district, but it would be easy for me to write to them and they might have some friends in common with me. Give me an idea of your intentions in this matter. M. Sauvalle must be in touch with you about the little scheme you two may be hatching. Please let him have these details. He will be good enough to pass them on to me.

Remember me to your wife and all your family and be sure of the devotion of your friend.

J. B. Fourier
Prefect of Isère

Notes

1. See above, Letter XII, n. 7.
2. See above, Letter IV, n. 4.
3. Ibid., n. 2.
4. The French lycées played a very important part in the educational system of the Consulate and Empire. They were founded by a decree of 2 Floreal Year X (1 May 1802). There was to be at least one in every region containing a court of appeal. The emphasis was much more on Latin and literature compared with the Écoles Centrales of the Directory with their bias towards science and mathematics. There was equally a new attention to discipline and this increased steadily under the Empire. Auxerre was unsuccessful in its attempt to have its École Centrale replaced by a lycée, and it had a content itself with a much less advanced École Secondaire. It only acquired a lycée—today the lycée Amygot—later in the century.

XV

Fourier to Bonard, no date

Grenoble the—Floreal—
To M. Bonard, Professor of
Mathematics at Auxerre

My dear Bonard,

I have a thousand apologies to make to you and I do not know how to justify myself for having remained so long without writing to you. Your friendship for me is a real refuge.

I shall be pleased if you will remember me to your wife and embrace all your family for me. Tell me what are your plans regarding the education of that one of your children of whom you spoke to me. If you wish him to enter a lycée I shall write specially to Fourcroy,[1] and if I am not deceived by the offer of help which he made me recently I hope you will quickly succeed in finding a place for him.

If you have some points to make to an old friend you must make up your mind to come and see me at Grenoble, and I believe it is the quickest way for us to agree together on an infinity of things. For you are not very regular in your correspondence and I am unpardonably negligent.

I have entirely forgotten how our accounts stand and I am sending the sum of 300 francs just in case. Kindly let me know what the position is about this.

Remember me to our old friends and colleagues, Messrs. Daru,[2] Mathon,[3] and Amé,[4] and if as I hope, you will be able to spend a few days with me, we shall talk about them here.

I beg you my dear Bonard to excuse my scrawl and to believe me your devoted and sincere friend.

J. B. Fourier

P.S. Be good enough to call in at my brother's and find out from him about the matter he is so keen for me to complete. I shall gladly do whatever he likes to suggest.

Notes

1. Fourcroy, Antoine François, Count (1755–1809). He belonged to an ancient legal family much reduced in circumstances, his father being a pharmacist in the House of Orléans. He left the Collège d'Harcourt at the age of fourteen with few attainments beyond a passion for music and poetry. Through the encouragement

of Vicq-d'Azyr he entered for medicine and became interested in chemistry. He made the acquaintance of Lavoisier in 1782 and was elected to a chair of chemistry at the Jardin du Roi in 1784 in preference to Berthollet. His lectures were celebrated for their brilliance and charm. He made important contributions to chemistry, both in collaboration with colleagues, especially Lavoisier, and by his analysis of various compounds. He became a member of the Académie des Sciences in 1785. He was elected a substitute deputy for Paris in the Convention and took his seat in July 1793 after the death of Marat, having worked unremittingly during the preceding eighteen months on ways and means of extracting and purifying saltpetre which had become in critically short supply as a result of the war between France and the European coalition. He became a very active member of the Committee of Public Education, playing a leading part in the dissolution of the ancient academies including the Académie des Sciences. He managed to have Desault, Chaptal, and Darcet released from prison but could—he later claimed—do nothing for Lavoisier. Later he was blamed for Lavoisier's death and though he defended himself from the charge with vehemence he could never entirely free himself from some measure of blame. He became a member of the Committee of Public Safety for a time after 9 Thermidor where he contributed to the establishment of the École Polytechnique. As Director General of Education under Napoleon from 1801 onwards he was largely responsible for the institution of the Napoleonic system of education including the setting up of lycées and the foundation of three schools of medicine at Paris, Montpellier, and Strasbourg. When Fontanes was chosen in 1808 as head of the Imperial University—a position to which Fourcroy had good claims and which he would have gladly filled—Fourcroy had to give up the educational side of his ministry, a surrender which he felt very keenly, and which may have contributed to his death the following year (*Bio. Gen.; Gde. Encycl.*).

2. A Daru is listed as one of Fourier's friends by Mauger.
3. See above, Letter XII, n. 7.
4. Ibid., n. 8.

XVI

Fourier to Bonard, no date

To M. Bonard,
Professor of Mathematics at
École Centrale

Melun 13 Germinal From the Prefect of Isère

My dear Bonard,

Sauvalle whom I saw several times at Paris will have warned you that I was going to ask permission to sleep one or two nights at your house on the occasion of my visit to Auxerre. As you see I have made use of this liberty which your friendship allows me.

I left Paris this evening, and, as I have promised to stop at Sens, I shall not arrive at Auxerre till the evening of the 15th. Once there I shall reply to your letter or rather I shall excuse myself if I can for having put off answering them.

I hope thus to renew with you an acquaintance which is beginning to become venerable and which will, I hope, never be broken.

Receive the assurance of my sincere [friendship].

J. B. Fourier

XVII

Fourier to an unknown correspondent, around 1810

I have the honour to send you:

(1) The work of M. Prévost on Radiant Heat.[1]

(2) An extract from the review which was given of this book in the *Mercure de France*.[2]

I had a search made for the whole number without success but have transcribed the part[3] of the review where the author of the articles describes the researches of M. Laplace[4] and the discoveries which were the fruit of these researches. Except by expressing oneself in a false and unjust manner I cannot be included among those who have been held up by this supposed analytical difficulty,[5] which a cursory examination soon dispels. It arises from the fact that (1) a differential quantity has been taken as a finite quantity, namely the heat that each section loses at its surface (2) a finite quantity has been expressed as a differential, namely the heat which one section communicates to the following one.

I have omitted to point out to you that this same author, who aided by the advice of M. Laplace has attempted to apply the equation of the linear movement of heat, thinks he has demonstrated the following result: that an iron bar whose extremity is immersed in a furnace at a given temperature cannot be heated sensibly at a distance of six feet from that extremity. He does not take account of the fact that the distance to which heat can be propagated in a bar depends on its thickness, and he could easily have seen this by establishing rigorously the equation in question. He first published this pretended discovery in the *Bibliothèque Brittanique*.[6] Since then he has referred again to the same proposition in a work on physics translated from Fischer[7] (see p. [ ]). M. Haüy[8] has also borrowed this error. I found it again in the work of M. Prévost,[9] p. 1. However the contrary is amply proved by experiment, and calculation demonstrates that the distance to which heat can be effectively propagated increases with the square root of the thickness.[10] This comment will provide you with a new proof of the small amount of care which he has given to the mathematical examination of these questions.

To treat with such lack of care one of the most important questions in analytical physics, to rush into publishing in periodical works speculations which are still uncertain and even erroneous, to found his reputation on a mutual exchange of [ ] and ridiculous flattery, to make use of public newspapers to foist on, and attribute to, others his own errors, and to

predispose others against a work which he does not dare to attack directly, and to attempt by a servile and calculated flattery to display as the inventor of an idea a person who is by no means such: that, Sir, is what I cannot observe without scorn. One can be assured that the majority of the public share this sentiment [ ]. I sincerely regret that M. Laplace does not realize that it is he himself who is supporting this attitude which is so false and so contrary to the progress of the sciences. The artifices that an author employs to exalt his own reputation beyond that which is reasonable never have lasting success and often involve him in bitter regrets.

As to the general principle about which M. Biot[11] talks which consists in the fact that the molecules of bodies which are immediately adjacent to each other act the one on the other for the transmission of heat, I do not understand why one would wish to set it up as a new truth. It has seemed inconceivable to me that the action in question could be restricted solely to surfaces in contact, and it is evident, or so it appears to me, that each point of an element should act on every point of neighbouring elements. It is no less certain that when the surface of a body is heated the heat which dissipates itself into the colder air comes not only from the extremity of the surface, but also from points which are beneath it at a very small distance. I can assure you that I have often employed these considerations in my researches. But I have recognized very clearly that it was not necessary [ ] for founding the theory of heat. Everything can be reduced to a proposition for which it is easy to give a rigorous demonstration: if a solid is contained between two infinite parallel planes whose distance is e: if the temperatures of each section decrease in arithmetic progression from the interior surface up to the opposite surface, the state of the system will be permanent, that is to say it will subsist in itself once it has been set up, and there will thereafter be no change in the temperature provided that one holds the two extreme sections (A) and (B) in the states which have just been assigned to them.

It is impossible to deny that this proposition is true and rigorously proved. Equally one cannot deny that it suffices to establish all the equations of the movement of heat. Finally, one cannot deny that the integrals given by the author exactly reproduce the phenomena. It is therefore false and unjust to insinuate indirectly that he has been held up by any analytical difficulty.

It is true that one can derive these same equations by considering the mutual actions of neighbouring molecules,[12] and that can be done also for the interior of a solid as I have shown in a note sent to M. Laplace.[13] But the application employed by M. Biot relative to the surface is entirely false. It is not thus that one should do it. Unless I am mistaken myself the temperatures of the extreme envelope of a body are not as M. Laplace or he

[Biot] represent them to be.[14] But I reserve for another time an observation in this matter.

I shall end this long letter by citing to you another example of the little care with which this theory has been examined. It has been pretended that the differential equations given by the author of the memoir had imaginary roots. For example, the equation $\tan x = 0$[15] was cited and it was continually objected that this equation had an infinity of imaginary roots, something which is contrary to the simplest elements of the calculus.

I could multiply remarks of this kind but the trouble which I would take would be importune and useless. The work I have given to the Institut would be for me the occasion of an embarrassing discussion. I propose to give up. I would prefer to lose so just a cause rather than defend it by means of public papers. I shall abandon this noble theatre to those who desire it for a career equally worthy. I shall restrict myself to devoting to science certain moments of leisure and I shall leave to others the difficult task of pointing out and [   ] intrigue. But that which I shall always retain is a just and sincere obligation to those, who like you Sir, are the true founders. May you long enjoy a glory so pure and so merited and bring back all minds to the true path by the authority of your lessons and of your examples. I beg you, Sir, to participate in the homage of my attachment and respect with which I am . . .

Notes

1. Prévost (2). Prévost, P. 1751–1839. From 1780–4 he was a member of the Berlin Academy and Professor of Philosophy in Berlin. Later he became Professor of Philosophy and Physics at the Academy of Geneva.
2. Biot (2). For a note on Biot see above Letter VII, n. 10, p. 273.
3. Ibid., p. 336.
4. Laplace (3), pp. 290–4.
5. Referred to in Biot (2), p. 336 and Laplace (3), p. 291.
6. Biot (1), p. 328.
7. Fischer.
8. It is not clear to which work of Haüy he refers.
9. Prévost (2).
10. This result is given in the 1807 memoir, art. 21.
11. Biot (2), p. 336 and Laplace (3), p. 291 maintained that the 'analytical difficulty' could be overcome by taking account of points of the bar other than those immediately adjacent to the point under consideration.
12. As in Laplace (3), pp. 291–4.
13. Possibly Letter XIX below.
14. See above, chapter 8, pp. 170–1 for a discussion of this.
15. This question continued to cause difficulties even after the publication of the Analytical Theory of Heat. See above, chapter 7, p. 155.

XVIII

Fourier to an unknown correspondent, around 1810

I see myself also obliged to discuss with you the memoir on the propagation of heat. I was imperfectly aware of the reflections[1] that M. Biot had inserted in the *Mercure de France*.[2] But having read this article myself I saw that [   ] the unfavourable intention of the author.

Without expressing oneself in a false and unjust manner one could not say that all the persons who undertook to treat this matter had been held up by an analytical difficulty[3] whose solution has just been discovered. This unkind allegation should not have been inserted in a newspaper, and it applies directly to my own researches announced long ago in the memoirs of a literary society of which M. Biot is a member.[4]

Far from having myself been held up in endeavouring to submit the theory of heat to calculation, I completely resolved questions of this kind and the table of matters given in my work alone proves that the allegation of M. Biot is unjustified.

Moreover the equations of movement of heat present themselves naturally and this first step encounters no difficulty. Doubtless by founding oneself on other considerations one can obtain the same equations.[5] They have this in common with all mathematical propositions, and it is the essence of truth. But it does not follow from that that the work of the author [   ] on heat is defective and that the results which he has discovered do not belong to him. When M. Biot considered the extremely simple case in which a solid reaches a constant state he was led certainly to an equation whose terms were not comparable.[6] But this arose uniquely from the small amount of attention which he gave to the establishment of the calculation, and not from any difficulty inherent in the question itself. Let x be the distance of the section from the furnace and y the temperature, then the quantity of heat which an elementary section transmits to the air is not represented by a finite term proportional to y but the differential term $Chy\,dx$, C being the circumference of the cross-section, h the measure of the exterior conductivity and dx the thickness of the section. On the other hand, the quantity of heat which passes from one section to another should not be represented by a differential term proportional to dy, but by a finite quantity which is a function of x, and this is very evident because the quantity of heat which traverses a section compensates exactly all that which diffuses through the rest of the surface. So M. Biot expresses in finite form a quantity which is differential, and on the other hand he represents a finite quantity by a differential quantity; this double irregularity would express a quantity infinitely small by a finite term, and on the other hand he writes a magnitude which is evidently finite by a differential term. But in that way this double omission has held him up himself. It is not reasonable to make a similar judgment on my own work where the question is treated and resolved with the most rigorous exactitude. It would be necessary that at least he expresses his opinion in a precise manner, and that he should, for example, among the large number of new propositions which I have derived indicate one single one which was either false or uncertain. But he shall never do this, and it is in fact impossible to attack the theory [ ] he can only retreat into vague expressions which exclude all formal replies. I beg you to consider, Sir, that the Institut should propose . . . as subject of a prize to treat the same question . . .[7]

Notes

1. See above, Letter XVII, para. 2.
2. Biot (2), p. 336.
3. Referred to in Biot (2), p. 336 and Laplace (3), p. 291.
4. A reference to Poisson's review (Poisson (2)) in the *Bulletin of the Société Philomatique*.
5. A reference to the derivation given by Laplace in Laplace (3), pp. 291–4.
6. This was the analytical difficulty encountered by Biot (see Biot (2), p. 336) to which reference was made in the second paragraph above.
7. Continuation illegible. Possibly the beginning of the campaign which led to the propagation of heat in solid bodies being chosen as the topic for the grand mathematical Prize of the Institut for 1811.

XIX

Fourier to an unknown correspondent, around 1810

When one began to determine by calculation the movement of heat in solid bodies one was held up by an analytical difficulty which consisted in the fact that the equations seemed to be made up of non-comparable terms.[1] It is asked[2] if the same difficulty subsists in the work which has been presented to the Institut on the theory of heat. The author of this memoir made no mention of the difficulty in question, he considered it unnecessary to recall the unfruitful attempts which had been made before him, but one can easily recognize that the equations which he proposes are made up of exactly comparable terms, and that there is no remaining uncertainty about the truth of these equations since they are all rigorously deduced from a principle[3] long since adopted and confirmed by all experiments. This principle can be annunciated as follows:

If two molecules A and B have different temperatures the quantity of heat which the warmer one transmits during an instant to the less warm one is, other things being equal, proportional to the difference of the two temperatures. Thus supposing that this difference were zero the molecules A and B would not exercise on one another any action which tends to change their temperatures. But if the initial difference of temperature is a the colder molecule will acquire during an instant δt a new quantity of heat, and if this initial difference had been $2a$, $3a$, $4a$, . . . the quantities of heat transmitted during the same instant by the hotter molecule would have been 2γ, 3γ, 4γ, . . . That is to say, the excess of the initial temperature being composed of a certain number of equal parts a, each of these parts acts as if it had produced an effect γ, in such a way that the total effect contains as many multiples of γ as the total excess of temperature contains a. Also if one adds to the initial temperature of the molecules a common magnitude the result of their mutual actions will not be changed. This principle must now be applied. A bar of any length whatsoever is held by its extremity A at the constant temperature 1, and from the point A is plunged in air which remains at temperature 0. It is supposed that the solid has acquired in each of these points a permanent temperature, and that all the points of a given section perpendicular to the length have sensibly the same temperature; x is the distance of a point of the axis to the point A, y is the temperature of this point. Here is how one attempted to determine by calculation the value of y in terms of x. The quantity of heat which a section placed at distance x transmits to that which follows it is according to the preceding principle proportional to $y-y'$ or δy. The quantity of heat that the second section transmits to that which follows it is proportional to $y'-y''$ or $-\delta y'$. Therefore the quantity of heat which any particular section actually acquires in an instant as a result of its position is proportional to the second difference $\delta^2 y$. On the other hand this same section allows a quantity of heat to escape into the air which is proportional to the excess of the temperature y over that of the air which is zero. But it is necessary that this loss should be compensated since the state of the bar is constant. Therefore in order to form the equation one should equate a term proportional to $\delta^2 y$ to a term which is proportional to y. These two terms are not comparable as they are, in this state, but since they become so on dividing the first by $\delta^2 x$ one has written the equation $\delta^2 y/\delta x^2 = Ay$, A[4] being an undetermined constant. This way of establishing the calculation seemed inexact because it furnished two terms which were not comparable, and in fact one cannot equate them except by making a change in the first for which one gives no reason drawn from the question itself.[5] On the other hand, the equations expressing the interior state of the solid, and that of the surface, cannot be obtained by this method in other problems; only a complete analysis of the conditions of the question can furnish these equations.

In spite of the simplicity of the preceding question the solution which has just been referred to is not satisfactory because it does not tell us how the dimensions of the solid, and the convective qualities, enter into the coefficient A.[6] It has even led to erroneous deductions, for example that a bar of iron held by one extremity in a furnace of heat cannot sensibly heat itself at a distance of six feet from the furnace.[7] If one tried in this way to determine the conductivity of different substances one would only obtain results which were vague and inapplicable. In order to judge if this defective manner of establishing calculations has been followed in the memoir on the theory of heat one should recall the principles employed by the author.

Since the solid has arrived at a permanent state the quantity of heat which traverses during unit time a single section placed at distance x is always the same. Moreover this quantity, which we designate by z, is necessarily equal to that which escapes during the same time in the air by all the parts of a surface which is to the right of the point x. Equally the quantity z' of heat which escapes by another section x' is equal to that which is lost in the same time by the part of the surface which is to the right of x'. Thus the difference $z-z'$ is equivalent to the quantity of heat which is lost during unit time by the part of the surface which is comprised between x and x'. However the quantity of heat which in unit time will flow out of a unit of surface held at all its points at temperature 1 has been denoted by h. It is therefore manifest that z and z' are quantities which are comparable to this number h. The quantity which measures the heat flowing through the section x is evidently a finite quantity which is a function of x, and the temperature y being represented by $f(x)$ the quantity z should be another function $\phi(x)$ of x. If C is the [circumference] of the section and the distance $x-x'$ is $\mathrm{d}x$ one will have

$$-\delta z = chy\,\delta x \quad \text{or} \quad -\delta z/\delta x = chy$$

It remains to determine the function z. But whatever it is, since it is certain that it represents, like the number h, a finite quantity, the equation is formed by terms which are exactly comparable and no change needs to be made to bring about that situation. But it has been rigorously proved in the memoir[8] that the function z is no other than $-kSf'(x)$, k being the conductivity proper of the solid, S the surface of a section, and $f'(x)$ denoting $\mathrm{d}y/\mathrm{d}x$. One will then have the equation

$$kS\,\mathrm{d}^2y/\mathrm{d}x^2 = chy.$$

To sum up, one sees why it is the solution which we have presented gives comparable terms.

1. The quantity of heat lost by the surface of the section is not only proportional to y but should also be expressed by $chydx$ which reduces this term at first to a differential of the first order.
2. The quantity of heat which passes from one section to another is proportional to the differential $\mathrm{d}z$. This quantity [z] is a fixed magnitude which is proportional to the function $f'(x)$ or $\mathrm{d}y/\mathrm{d}x$. It is therefore the differential of this function, or $f''(x)\,\mathrm{d}x$, which should be compared to $chy\,\mathrm{d}x$, and now there is no sort of inhomogeneity whatsoever.

Thus everything reduces to noting that the magnitude designated by z is not a differential but a finite quantity which is a certain multiple of the number h. But of all the ways of being assured of the truth of this there can be no other which is clearer or more simple than that which precedes. It consists in noting that this quantity is necessarily equivalent to the quantity of heat which is lost in the same time by the whole surface of the solid which is to the right of the point x.

Later one will see the means which have been employed to establish the equations of the motion of heat in much more complicated questions. One will find that they are no less rigorous and that there is no sort of uncertainty on the nature of the terms compared.

Doubtless by basing oneself on different considerations one can obtain the same equations. They have that in common with all mathematical propositions and it is the characteristic of that which is true. But just because one discovers another way to arrive at the same result it does not follow that the author's work has been defective or that his results do not belong to him.[9] Without expressing oneself in a false and unjust manner one cannot say that all persons up to date who have attempted to submit to calculation the theory of heat have been held up by the above mentioned difficulties[10] . . . and the contrary is proved by the table of matters treated in the memoir alone. The persons to whom this work is presented and who wish to examine it cannot but disapprove of such an unfounded allegation. It is unseemly to insert it in advance in public periodicals[11], and to lecture the public on questions which one has studied so badly. It is to make a very unworthy use of both talent and time.

To render the preceding notes more complete it is necessary to recall how one proves that the function designated by z has the expression $-kSf'(x)$. For that one considers [ ] of the prismatic bar as a solid comprised between two infinitely prolonged planes one of these faces being maintained at the constant temperature y and the other at the constant temperature $y+\mathrm{d}y$. But it is easy to determine the movement of heat in such a solid and subsequently to apply the result to the section whose thickness is $\mathrm{d}x$.

Let[12] M be a solid comprised between two parallel infinite planes, e the distance between the planes, a the permanent temperature of the first surface, and b that of the opposite surface. One sees easily that when the state of the solid has become steady the interior temperatures decrease from A to B as the ordinates of a straight line. In fact, if the temperatures were so there would be no change in the state of the solid and the heat would continue to move uniformly from A to B. To assure oneself of this it is sufficient to remark that the temperatures being unequal at every instant a new quantity of heat traverses any particular section of the prism. But one proves that this quantity which flows during a given time is the same for the section m as for any other section n. Therefore the solid comprised between m and n receives [ ] as much heat as it loses. It should therefore maintain its state, and it is the same for all the other parts. It remains to prove this equality of the quantities of heat traversing any two sections. For that we shall consider a part AD of the solid which can be divided in two equal parts at point C. Let us compare the state of the part CD to that of the part AC. It is clear that if one adds a common quantity to all the temperatures of the solid CD one will change in no way the mutual action of the molecules, and in consequence the same quantity of heat will still traverse the mean section n. But by this addition of a certain common quantity to all the temperatures of CD one makes them equal to the temperatures of AC. Therefore there flows by the mean section m [of AC] just as much heat as by the mean section n [of CD]. From this one sees that if the temperatures decrease as supposed in arithmetical progression the solid will be continually traversed by a uniform current of heat, and consequently its state should not change, which was what had to be proved.

It is necessary now to find the nature of this quantity of heat which traverses the part AB. Suppose that in another equal solid one of the faces is at temperature $2a$ and the other at temperature $2b$. When its state becomes permanent the interior temperatures will decrease from $2a$ down to $2b$ in arithmetic progression. They will therefore be very different from those which were found in the first solid. If two molecules p and q in the first case had temperatures whose difference was α, the same molecules of the second solid would have temperatures whose difference would be 2α. If therefore [ ] transmit heat the result of this action being in the first case α it will be 2α in the second case, and it will be the same for any two molecules whatsoever equally placed in one and the other solid. From this it necessarily follows that the whole quantity of heat which crosses a section m of the second solid is double the quantity which traverses the same section of the first. Therefore, in general, to compare the state of two equal solids whose faces are maintained at unequal temperatures it suffices to compare the temperatures of two molecules p and q whose distance is r, to those of two molecules of the second solid which are at the same distance r. If the excess of the temperatures is α in the first solid and α' in the second, the quantities of heat which traverse uniformly one or other prism will be between themselves in the ratio α to α'.

It follows from this that the measure of this quantity of heat in the first solid considered is $kS(a-b)e$, the number k being the same for the bodies formed of the same substance but different for solids of another material, and S being the extent of the surface of the section traversed by the current of heat [ ]. By applying this result to the infinitely small section whose thickness is $\mathrm{d}x$, whose extreme temperatures are y and $y+\mathrm{d}y$, and whose section is S one has

$$-kS(\mathrm{d}y/\mathrm{d}x) \quad \text{or} \quad -kSf'(x)$$

The demonstration that one has just given may give rise to the following questions:

1. It is asked[13] if in the solid comprised between the two planes A and B the quantity of heat which crosses a point of a section m arises solely from the action of two molecules p and q infinitely close together, or if there are not other molecules p' and q' which being even separated by the preceding p and q act one on the other, in such a way that the colder q' receives from the warmer p' a certain quantity of heat. We reply as follows to this question.

If two molecules p' and q' separated by the molecules p and q are also sufficiently close to transmit a certain quantity of heat γ', and the two molecules p' and q' exercise their action in a solid whose extreme temperatures are a and b, and in one in which the extreme temperatures are $2a$ and $2b$. If in the first case the difference of their temperatures is α' and the result of their action γ', this difference will be $2\alpha'$ in the case of $2a$ and $2b$, and consequently p' will transmit to q' a quantity of heat equal to $2\gamma'$. It is therefore certain that the quantity of heat which crosses the point m is twice as great in the second solid as in the first whether the heat transmitted arises solely from the action of p and q or from that of a multitude of systems of two molecules. The preceding demonstration applies to each part of the total effect and consequently to the sum of these effects.

Moreover one cannot reduce the effect in question to that of two individual parts in contact. That is inconceivable in continuous solids and it is the whole slice $mpp'P$ which acts on the whole slice $mqq'Q$. One cannot doubt but that this action consists in a sort of radiation, and that heat transmits itself in the interior of solids in the same manner as in air and at the surface of bodies. Only the distance up to which two molecules exercise on one another a sensible action is incomparably smaller in a solid than in an elastic fluid. This distance is very considerable in air and from the experiments of M. Leslie one knows that a leaf of gold even when it has become transparent and of the greatest thinness stops the direct transmission of heat. The preceding demonstration neither supposes nor excludes these physical considerations, and whether the distance in question be infinitely small or finite, it is incontestable that the quantity of heat transmitted has for its expression the term $kS(a-b)/e$. Although in what follows one makes application of this result to the varied movement of heat in solids, one supposes implicitly that the distance at which two points no longer exercise any sensible action is extremely small as is shown by all experiments.

2. If one objects that it is not obvious that the principle given by Newton can serve as a basis for the theory of heat, the author would reply that the proposition in question is confirmed by multiple observations and that it is accepted by all physicists. One can moreover go back to the origin of this principle or replace it by other considerations. But if it is always necessary to start with a primordial fact that can be verified by experiment alone let us imagine, for example, that two such material points p and q act one on the other for the transmission of heat in the interior of a solid, and that there is between these molecules an exchange of heat as there would be an exchange of light if they were both illuminated. Let r be their distance, U the quantity of heat accumulated in the point p, V the heat of the point q, and a the difference $V-U$ which is infinitely small compared to V. The quantity of heat sent by q would be given by $\phi(r, V)$, ϕ indicating a certain function which depends on the nature of the solid and also [ ], $\phi(r, U)$ for the quantity of heat sent by the point p. Therefore the result of the mutual action which would be necessary to change the temperatures is given by $\phi(r, V)-\psi(r, U)$ or $a\phi'(rU)$. Now if one adds a common quantity A to the two quantities V and U one knows by repeated observations that the mutual action of the two molecules will not be changed. Therefore $a\phi'(r, U+A)$ is the same thing as $a\phi'(r, U)$. By that one sees that the coefficient $\phi'(t, U)$ in the expression $a\phi'(r, U)$ is a quantity independent of U, and that all other things being equal the action of the molecules is proportional to the difference a of the temperatures, which is the principle of Newton. One ought to substitute for this principle the general fact which has just been mentioned. It consists in the fact that phenomena depending on the transmission of heat remain sensibly the same when all temperatures are increased by a constant quantity. But this last result [ ] by the observations of Newton, Rickmann, and Kraft, those of Lambert, of Count Rumford, and of Messrs. Leslie and Biot.[14] In a word by all those persons who have made the most varied experiments on the same subject. No matter what the outcome of the preceding considerations, and even if one does not agree with them, it has nevertheless always been rigorously proved that the results announced in the memoir are the necessary consequences of a single principle adopted by all the physicists who have studied the phenomena of heat.

It suffices to look at the table of matters which have been treated in the memoir on the Propagation of Heat to recognize that the author has taken the greatest care to deepen this theory and that he has solved all the fundamental questions. He has given the general equations for the movement of heat and those belonging to the state of the surface, and has applied them to the most important cases, and he has later given integrals of these equations in the forms most appropriate to the nature of the physical questions which he has treated. The formulae which he has deduced can be applied easily. They represent in the clearest manner all the circumstances of the propagation of heat in the interior of solids. They contain exact definitions of the diverse properties of bodies relative to this transmission, namely the capacity of heat[15] and the conductive qualities.[16] They furnish the means of distinguishing and measuring these properties. They show the nature of the movement of heat in a sphere,[17] in a ring,[18] in a cubic solid[19] and in a prismatic solid.[20] This theory is applicable to that of the problem of terrestrial temperatures.[21] It is confirmed by experiments which the author has made himself with attention and perseverance.[22] One should not therefore announce, even indirectly, that he has been held up in this theory, for the contrary is proved by the table of matters alone.

In order that one might judge more easily whether or not the equations which express the movement of heat are established on sound principles one will recall the propositions which are in question:

1. The quantity of heat which flows in a given time across the section of a prismatic bar which has reached a permanent temperature, is equal to that which escapes in the air by a definite part of the surface of a solid. This quantity is represented, like the temperature, by a function z of the distance x. The equation sought for is $-\mathrm{d}z/\mathrm{d}x = chy$ which involves only comparable terms.
2. That if a solid comprised between two infinite parallel planes at distance e apart acquires permanent temperatures, one of the faces being held at temperature a and the opposite face at temperature b, the intermediate sections [ ] will have temperatures decreasing from a to b in arithmetic progression, and the quantity of heat which flows uniformly in the solid by a section S of the section is equal to the quantity $-kS$ $(a-b)/e$, k being the specific conductibility.
3. The function designated by z in the second [*sic*] proposition is equal to $kSf'(x)$ and the equation which expresses the linear movement of heat is

$$kS\,\mathrm{d}^2y/\mathrm{d}x^2 = chy.$$

For one to be able to consider as non-rigorous the methods adopted by the author for establishing these equations it would be necessary to indicate as either false or doubtful one or other of the preceding propositions.

Notes

1. He is evidently referring to his treatment in the Draft Paper. See above, chapter 8, p. 164–5.
2. By Biot and Laplace among others.
3. Newton's principle, first enunciated for the case of the loss of heat at the surface of a heated sphere immersed in air maintained at a constant temperature. See entry under Newton in Bibliography.
4. Fourier employs this symbol here in spite of its quite different earlier meaning as one end of the bar.
5. For the 'argument' given in the Draft Paper see above, chapter 8, p. 164–5.
6. This was also a weakness of Laplace's derivation in Laplace (3): see above, chapter 9, p. 184.
7. This unfortunate 'deduction' was made in Biot (1), p. 338.
8. See 1807 memoir, art. 17.
9. The passage back to the beginning of the paragraph should be compared with that given in para. 4 of Letter XVIII above.
10. He refers to the same difficulty in para. 1 of Letter XVII above.

11. The same complaint is made in Letters XVII and XVIII above. Fourier himself was careful to restrict his criticisms of Biot—and later Poisson—to private correspondence. As he said in a note to Letter XXI 'it will be more difficult to cite M. Biot because I wish to avoid saying in public what I think of his writing on the subject'.
12. The following derivation of the expression for the heat flux represents a fundamental improvement on that given in the 1807 memoir. See above, chapter 9, p. 186.
13. Probably by Biot and Laplace who had implied (Biot (2), p. 336 and Laplace (3), p. 291) that the famous 'analytical difficulty' could only be surmounted by taking account of 'molecules' other than those immediately adjacent to the point of the bar considered.
14. In the case of Lambert and Leslie he would be referring to the works given in the Bibliography. The other references are uncertain apart from Biot (1).
15. See 1807 memoir, art. 15.
16. Ibid., arts. 16, 17.
17. Ibid., arts. 100–14.
18. Ibid., arts. 76–94.
19. Ibid., arts. 152–8.
20. Ibid., arts. 140–51.
21. As given for the first time in arts. 80–8 of the Prize Essay.
22. Fourier refers to such experiments in the Historical Notes, and in the Historical Précis fol. 162. They are recounted in arts. 159–67 of the 1807 memoir.

XX

Fourier to Laplace, around 1808–9

I have the honour to offer to M. Laplace the homage of my regards in sending him the attached note on certain analytical expressions in connection with the theory of heat.

The function cos x is developed in terms of multiple arcs as follows:[1]

$$\tfrac{1}{2}\pi \cos x = (\tfrac{1}{1}+\tfrac{1}{3})\sin 2x+(\tfrac{1}{3}+\tfrac{1}{5})\sin 4x+(\tfrac{1}{5}+\tfrac{1}{7})\sin 6x+\cdots \tag{1}$$

The function sin x is developed in terms of multiple arcs as follows:[2]

$$\frac{1}{4}\pi \sin x = \frac{1}{2}-\frac{\cos 2x}{1.2}-\frac{\cos 4x}{3\cdot 5}-\frac{\cos 6x}{5\cdot 7}-\frac{\cos 8x}{7\cdot 9}-\cdots \tag{2}$$

These theorems are not contrary to the principles of the calculus.[3] They may be demonstrated rigorously and the demonstration not only consists in the procedure which serves to determine the coefficients; it consists also in proving that if one sets in place of x in the equations (1) and (2) any value whatsoever comprised between certain limits the second number is a determined value which is equal to that of the first.

The series (1) and (2) are convergent and in general this property holds without exception for all the series which I have employed in the Analytical Theory of Heat.

For example the infinite series[4]

$$\sin x+\frac{\sin 3x}{3^2}+\frac{\sin 5x}{5^2}+\cdots$$

is convergent and it expresses the ordinate of the contour of an isosceles triangle the value of x being comprised between certain limits. Of all the propositions of this kind the most simple is the principal one

$$\frac{1}{4}\pi = \sin x+\frac{\sin 3x}{3}+\frac{\sin 5x}{5}+\cdots$$

which contains the series of Leibniz.

One can demonstrate in different ways the convergence of these series. Here is the procedure[5] which I have most often employed because it cannot leave any doubt. One considers first the number m of terms as finite and known. One looks for the exact expression of the sum of the terms as a function of x and m. One develops this function according to

reciprocal powers of m and one recognizes that the more the number m increases the more each term diminishes except the first. One remarks that this latter term is the limit of the series. But this term is the first number of the equation. The same calculation clearly shows between which limits the calculation holds.

The question of the convergence of the series is here considered only in regard to an understanding of the validity of the equation and disregarding the use made of the same series to find numerical values. This kind of approximation would be too slow. But in the equations of the theory of heat the terms of these theories are multiplied by exponentials which contain the time as a result of which the convergence is extremely rapid.[6]

Notes

1. See 1807 memoir, p. 222.
2. Ibid., p. 228.
3. Presumably Laplace had said they were.
4. See 1807 memoir, p. 227.
5. First given in section 4 (fol. 142) of the Draft Paper and reproduced in article 47 of the 1807 memoir.
6. A good example of Fourier's intensely pragmatic approach to mathematics, at least in the *Analytical Theory of Heat,* as a tool for obtaining workable solutions to physical problems.

XXI

Fourier to an unknown correspondent, around 1808–9

I have the honour to send you two notes concerning the memoir on heat. The first[1] is the one which was read at the Institut in place of the reading of the memoir. The second[2] contains a more detailed discussion of the equation

$$\tfrac{1}{2}x = \sin x - \tfrac{1}{2}\sin 2x + \tfrac{1}{3}\sin 3x \ldots$$

I beg you instantly to cast your eyes on this second note which clearly establishes the convergence of this series and of which the essential part was already in the memoir (article [44]).[3] You will easily recognize that this matter is not a question of faith but of mathematics, a very different thing, and it seems to me that if such demonstrations are to be forbidden, it will be necessary to give up writing anything exact in mathematics. I can assure you, Sir, that I have advanced in this memoir nothing whose truth has not been established by the most careful examination in which very different methods have been brought to bear. But I have suppressed these details which would have rightly been regarded as unnecessary.

I arrived at the developments of functions in sines or cosines of multiple arcs by the method of elimination. Having later[4] solved the problem posed by an infinity of bodies communicating heat between each other, I recognized that the development would also apply to an arbitrary function and I arrived by an entirely different[5] method at the same equation

$$\tfrac{1}{2}\pi\phi(x) = \sin x\int\phi(x)\sin x\,\mathrm{d}x + \sin 2x\int\phi(x)\sin 2x\,\mathrm{d}x + \cdots$$

which I had obtained previously. I transmitted this part of my work two years ago to M. Biot and M. Poisson who then knew the use I was making of it to express the integrals of partial differential equations in trigonometrical or exponential series: they did not point out to me that d'Alembert or Euler had employed these integrations to develop a trigonometrical solution. I was ignorant of the fact myself or I had entirely forgotten it; it was in attempting to verify a third theorem that I employed the procedure which consists in multiplying by cosi x dx the two sides of the equation

$$\phi(x) = a_0 + a_1\cos x + a_2\cos 2x + \cdots$$

and integrating between $x = 0$ and $x = \pi$. I am sorry not to have known the mathematician who first made use of this method because I would have cited him.* Regarding the researches[6] of d'Alembert and Euler could one not add that if they knew this expansion they made but a very imperfect use of it. They were both persuaded that an arbitrary and discontinous function could never be resolved in series of this kind, and it does not even seem that anyone had developed a constant in cosines of multiple arcs, the first problem which I had to solve in the theory of heat. It was also necessary to know the limits between which this development took place. For example it has to be realized that the equation[7]

$$x/2 = \sin x - \tfrac{1}{2}\sin 2x + \tfrac{1}{3}\sin 3x \ldots$$

is no longer true when the value of x is between π and 2π. However, the second side of the equation is still a convergent series but the sum is not equal to $x/2$. Euler, who knew this equation, gave it without comment. It is very clear that if the method used to develop certain functions in trigonometrical series had been entirely exact it would have made known the limits between which the equations held true. Finally, this development of a function in sines or cosines of multiple arcs is only a particular case among those which I have had to treat, and these latter offered analytical difficulties of a very different order. It was necessary, for example, for determining the movement of heat in a cylindrical body to develop an arbitrary function in a series whose terms depended on a transcendental function given by a differential equation of the second order.[8] I beg you, Sir, to be good enough to examine this part of my work which is really the only part worthy of your attention.

I did not intend to denigrate the work which had been done before me by mathematicians as illustrious as Messrs d'Alembert and Euler for I hold their memories in the deepest respect. But I have wished to make it clear that the procedure which they made use of was not adequate to solve the problems relating to the theory of heat.

Moreover, Sir, if I had to cite certain works it would have been principally yours of which I have made an attentive study in the past and which contain in fact on the question of series, on partial differential equations, the elimination of coefficients, and the consideration of an infinite number of differential equations, a multitude of elements similar to those employed by me. Accept this as a reason for claiming your attention, and I beg you instantly to read all the section of my work where I consider the development of series. After this reading you will readily see that there is nothing which is not incontestable. In fact one can well object that there exists in the analysis certain trigonometrical series whose values are vague, that often in this matter the results present themselves in diverse and opposed forms, that several of the results of the memoir have paradoxical implications, and that in dealing with propositions of this kind the more they lack solid proofs the more one attempts to justify them. But those are the sort of general reasonings which apply universally, for example to the quadrature of the circle, which have not even the advantage of being new and with which one can combat either error or truth as the need arises. These maxims do not dispense with the need for examining things in themselves in order to avoid lumping together those which are entirely different, and because there were formally certain obscurities in the theory of infinite limits it does not at all follow that these obscurities are in my work. Finally, Sir, the end which I have proposed to myself is to determine the movement of heat in solid bodies by means of the analysis of partial differential equations. This question is in itself sufficiently important to merit the attention of mathematicians, and it is really useful to know if the results announced are erroneous or if applications can be made of them.

I desire, above all, to recommend my work to your attention for other reasons and to remind you of the tokens of your benevolence which you have given to the author. My heart will always guard their memory and I attach to these relations an entirely different value than to cold, and as it were indifferent, truths.

Excuse therefore, Sir, the length of this letter, and be very sure that it is written by one who honours you and admires you and who joins to the public gratitude which is due to you, the personal homage of the most respectful attachment.

I have the honour to be with these sentiments, Sir, your very humble and very obedient servant Fourier.

NOTE * I was not able to consult any mathematical works at the time of undertaking these researches, but when I publish them I shall regard it as my duty to insert the missing (historical) citations. For this reason I shall endeavour to find out about the work of Lambert which seems to have treated the same subject. It will be more difficult to cite M. Biot because I wish to avoid saying in public what I think of his writing on the subject.

Notes

1. This was the abstract (*extrait*) of Fourier's 1807 memoir which has been retained in the MS. 1851 of the library of the Nationale École des Ponts et Chaussées, Paris. It must therefore be dated 1807, and not 1809 as suggested by Grattan-Guinness (3), p. 497.
2. Also found in above MS. 1851. It is effectively identical with the treatment of the same series given in art. 44 of the same memoir, as Fourier himself notes below.
3. The question of convergence of certain trigonometrical series had first been treated in the Draft Paper.

4. Sometime between the composition of the Draft Paper and the completion of the 1807 memoir.
5. Different, that is, from the method based on elimination by which he had first obtained this equation, as given in the 1807 memoir, arts. 50–61. The different method is evidently that based on integration to which he refers immediately afterwards.
6. See a recent discussion of this in Grattan-Guinness (3), chapter 10.
7. See 1807 memoir, arts. 122–39.
8. Some forty years later William Thomson, Lord Kelvin, was full of admiration for this part of Fourier's treatise:

> when it was printed in 1821 [*sic*], and published after having with the rest of Fourier's work been buried alive for fourteen years in the archives of the French Academy, and when Bessel found in it so thorough an investigation and so strikingly beautiful an application of the *Besselsche Funxtion* we can imagine the ordinary feeling towards those *qui ante nos nostra dixerunt* reversed into the pleasure of genuine admiration.

(Thomson, W., *Math. Phys. Pap.*, **2**, p. 52).

XXII

Fourier to Bonard, February 1810

Paris, 25 February 1810

My dear old friend,

I do not know how to ask your forgiveness for the continual delays in my correspondence, though they can only in part be blamed on my negligence; for the circumstances in which I have found myself for several months have demanded my exclusive and total attention.

I have written today to Grenoble and instructed the person responsible for my affairs to send you immediately the sum of 800 francs to which you refer in your letter.

My letter will arrive on 1 February [*sic*] and you will certainly receive the sum in question by the 6th and 7th of next month. If, however, you find this delay somewhat inconvenient please be good enough to write to M. Guichard, the post office director, and request from him on my behalf the sum of 800 francs. I know his friendship for me well enough to be certain that he will accede to your request. Please give my regards to Mme Bonard and thank her for what she has done for my niece. I shall do my best on my return to spend a day or two at Auxerre. When you remember me to M. Guichard, tell him how much I regret not having seen him when he was last at Paris; I often meet M. Dumoland, his friend, at court and we talk about him.

At last I am coming to the end of my troubles, the printing of my discourse[1] will soon be finished. I shall then devote more time and care to my personal affairs. In continuing to have recourse to your kindness I shall try to repay it better than I have done up to the present. Please remember me to M. Roux[2] and give me news of his health.

Accept the assurance of all the feelings of gratitude which I owe to your long standing friendship.

P.S. J. Fourier
Prefect of Isère

Notes

1. His Introduction to the *Description of Egypt*.
2. See above, Letter IV, n. 2.

XXIII

Fourier to the Minister of the Interior, March 1815

Lyons 25 March 1815

Sir,

I have the honour to address to your excellency[1] a certified copy of the imperial decree of the 12th of this month by which his majesty was pleased to call me to the office of the Prefect of the department of the Rhône in which I was installed the same day in accordance with the enclosed report.

I am with respect, Sir, your excellency's most humble and most obedient servant.

The prefect of the department of the Rhône,
Fourier

Notes

1. Carnot, L. N. M. (1753–1823). Having completed his early studies at the College of Autun, his remarkable aptitude for mathematics and science prompted his father to send him to a preparatory school in Paris for prospective cadets for the engineers and artillery run by a friend of D'Alembert. From here he passed to the school of Military Engineering at Mézières (1771) where he was a pupil of his compatriot Gaspard Monge. He left Mézières in 1773 and entered the corps of engineers where he found time to compose an *Éloge de Vaubin* and his important *Essai sur les Machines en Géneral* (1783) containing the theorem on colliding bodies bearing his name. In 1788 he was imprisoned for a time through a *lettre de cachet* resulting from his somewhat ungallant action in relation to a certain Mlle Bouillet. In September 1789 he addressed a memoir to the National Assembly against the oppressive régime governing the engineering corps in which he demanded the creation of a committee of officers elected by their peers. In 1792 he was elected (along with his brother Claude-Marie) to the Legislative Assembly where he became a member of the Committee of Public Instruction and made a name for his interventions in military affairs. He was elected to the Convention where he voted for the death of the King. His role in the period 1793 to 1797 belongs to European History. He disapproved of the Empire and spent the period 1804 to 1814 in retirement devoting himself to the education of his children, his scientific work, and to playing a full part in the day to day life of the First Class of the Institut to which he had been elected in 1796. He emerged from retirement in 1814 to become governor of Antwerp, and during the Hundred Days he was Minister of the Interior. This led to his exile after Waterloo and he died in Magdeburg in 1823. Carnot's stature as a savant has tended to be ignored in comparison with the political and military side of his life, but is now under active consideration (*Bio. Gen.; Gde. Encycl.*; see also Gillispie).

XXIV

Fourier to the Minister of the Interior, March 1815

Lyons 30 March 1815.

Sir,

I have the honour to acknowledge reception of your excellency's letter written to me on 22nd of this month informing me that his majesty the Emperor had recalled you to the Ministry of the Interior.

France will find in this change, Sir, a new proof of the clear views of his majesty; but while France and Europe applaud this striking testimony rendered to you, the administrative authorities will be particularly conscious of its value.

I will not talk to your excellency of the sentiments of devotion which attach me to his majesty. They have been long known. Public opinion in the department which I have the honour to administer has expressed itself in a manner to leave no doubt as to the opinion of the inhabitants, and if there still exist some partisans of the previous government they are few in number and without influence.

All the official proclamations printed in the *Moniteur* have been printed, published, and displayed at various times in all the communes of the department. The official bulletins and telegraphic dispatches have also been published immediately after their arrival and help to strengthen public opinion which could still be led astray by some new lies spread about intentionally. And so from this point of view your excellency's instructions have already been carried out and will continue to be punctually.

As to municipal officers, very few changes have been made, they have been restricted to a few members...

XXV

Fourier to sub-prefects of the Department of the Rhône, May 1815

Lyons 1 May 1815

M. Sub Prefect,

I have the honour to address to you the enclosed circulars which I have written to mayors of the communes concerning the publication of the *acte additionel*[1] to the imperial constitution and to the execution of the imperial decree which orders the opening of registers on which the votes of Frenchmen are to be inscribed.

I enclose with the present letter several copies of this act which should remain in the secretariat of the sub-prefecture so that the voters can acquaint themselves with it.

I request you, M. Sub Prefect, to pass on immediately, and by express post, to the mayors of the communes of your district the packets which are intended for them, and to make sure that the registers are opened wherever they should be.

I have fixed the closing of the registers for the 12th of this month and I have instructed the mayors to see that they reach you in the course of the 15th.

On the 16th you are to make a report of the votes cast in the communes of your district. This report, in conformity with model 2, and which you will prepare in advance, should be sent the next day in duplicate with the registers of the votes. Under no circumstances, M. Sub Prefect, should this dispatch be subject to the least delay. It is indispensable that on the 17th of this month all the papers should be returned to me.

I request you to bring all possible promptness and speed to these matters so that I may be able to send his excellency the Minister of the Interior, within the delay fixed by his instructions, the results for submission to the assembly of the Field of May.

Receive M. Sub Prefect the assurance of my distinguished regard.

The Prefect of the Rhône
Count Fourier

Note

1. See above, chapter 5, n. 78, p. 116.

XXVI

Fourier to the Ministers of War, Police, and the Interior, May 1815

Lyons, 6 May 1815

Sir,

The examining council finished its operations on the 3rd of this month. The number of returned soldiers available has risen to 12 900. The first departure took place today, 220 men were dispatched for various corps; new detachments will be sent off every day.

I shall have the honour to send you, Sir, without delay the municipal returns of the soldiers called before the council, of those who appeared, and the decisions which were taken.

The recruiting officers occupy one of the offices of the prefecture, and I have them supplied with the material necessary for their writing. There are already some white forms left by the former recruiting captains, but they will not be enough to provide for duplicate copies: I am having others printed . . .

Fourier

XXVII

Fourier to the Minister of the Interior, March 1816

Paris,
28 March, 1816

To His Excellency the Minister and Secretary of State for the Interior.[1]

Sir,

I received with the keenest sorrow the reply which your Excellency has just sent me concerning my demand for a retirement pension. I have devoted to the State my life and talents during thirty consecutive years, namely thirteen years in public education and seventeen in administration. I have contributed as Professor of Analysis to the establishment of the École Polytechnique of France. Your Excellency knows the part I played in the composition of the memoirs on Egypt. I am the only one of the authors of this great work who has received no payment, nor pension, nor indemnity. I administered the department of Isère during thirteen years and I leave public office without any fortune. The principles which directed my conduct in this period are perhaps forgotten today by the government, but they are well known in the ancient province of the Dauphinée. The services I rendered to so many families then in need of support deserve to be taken into consideration. The drying of the marshes of Bourgoin was commenced and entirely completed under my administration. The agricultural territory of France received considerable increase (about 19 000 acres). The annual illnesses which cut short men's lives have ceased for ever in this region. Public wealth has been augmented by many millions. Your Excellency knows the deliberations of the forty interested communes and of the general council of the department, those of the proprietors and of the concessionaries, and in the light of their expression of gratitude and their formal declarations one cannot doubt that I was the principal author of this enterprise. It required a special effort on my part continued over eleven years, and considerable expenses for which I have never been compensated. I have served France in difficult times, full of dangers of every kind; I have served her in towns, in camps, in far countries, in the midst of seditions, wars, and contagious diseases. As a man of letters I have contributed gratuitously to a precious monument which honours our country and which will long be remembered in the history of the arts. My youth was consecrated to teaching the sciences in the foremost places of education; finally as an administrator I participated in the greatest and most useful public work which has been executed in France in recent times.[a] No political motive should efface the memory of so many services from which the State and many generations will receive real and lasting advantages. I realize how out of place it is to speak thus of oneself, and it is as painful to me as it is contrary to good manners thus to recall the outcome of my efforts; but I may be excused if one remembers the absolute obligation under which I find myself to make the most of my services by all means consistent with the truth.

As to the political facts which have been brought against me, one cannot judge them fairly without taking careful account of the circumstances in which I found myself.

The outcome of the inquest into the trial of General Marchand[2] has just proved that I made the greatest efforts to check the spirit of sedition in the department of Isère. Your Excellency has moreover an incontestable proof of this in the attached letter which I beg you instantly to read.[b] I shall restrict myself to enumerating the principal facts the formal evidence for these facts being cited in my memoir.

I had arrested and conducted to the prisons of Grenoble and other towns fifteen of the principal agitators.

An act entitled 'Imperial Decree' dated Grenoble, 9 March, published and displayed in this town and in the neighbouring departments, dismissed me from my position and required me to leave the territory of the Seventh Military Division under penalty of being treated as an enemy of the State.[3]

I upheld the exercise of the King's authority wherever I was, and this authority did not cease till I had been arrested by the advance guard and conducted to Bourgoin to Bonaparte's headquarters.

I visited the banks of the Rhône to co-operate in the destruction of bridges and the removal of ferry boats, important and decisive measures which I constantly advocated orally and in writing and which could alone have prevented the usurpation of the territory beyond that river. I was on the way to Lyons when from that town I received a written order[4] from His Royal Highness, Monsieur, ordering me to return to the department of Isère and go back towards Grenoble. It was in obeying this instruction that I was captured at Lerezin by order of Bonaparte and conducted to his headquarters at Bourgoin in the midst of an immense crowd of mutineers and soldiers. From that moment I lost all liberty of action and what I did could not be imputed to me as a voluntary act. It is well known that I resisted as long as possible what Bonaparte intended for me, and I yielded to a violent and formidable power to which my previous actions had been opposed. It is at least certain that I made use of my authority only to prevent, stop, and repair great misfortunes. I only exercised this authority after the reiterated demands of a large number of the principal inhabitants who were exposed to great peril through their attachment to the royal cause. I may add that I refused absolutely to participate in any act of dismissal, replacement, or arrest. I will not attempt to justify my sustained opposition to Messrs. de Grouchi, Brayer, and the extraordinary commissioner M. Maret. These facts are public property in the two departments of Isère and of the Rhône. It is equally well known that I refused formally and in writing to participate in the acts required of me. I was then replaced by Monsieur Pons as is proved by an act entitled 'Imperial Decree' dated Paris, 17 May.[5]

If the facts I advance are true, and if my previous services actually are as I have related them, are the rights to which these services entitle me to be irrevocably destroyed? Should neither my disinterestedness nor my zeal count for something, nor my constant opposition to all oppressive measures, nor the benefits which I have obtained for the State, nor the principles which I have followed during thirteen consecutive years in a time when these principles certainly could not have been suggested to me by any political consideration. The King's justice and virtue will not allow one of the most senior administrators of France, one who has consecrated his life to useful works, and to the progress of science and letters, to remain without any personal fortune and unindemnified while the state and [other] individuals alone enjoy the fruit of *his* labours. It is from this point of view, Excellency, that I am obliged to renew my demands to your Ministry for a pension as former professor of the École Polytechnique, as one of the principal authors of the Egyptian collection, and as a former prefect. Allow me to call again on your benovolence and support in such a just cause which concerns both administration and the arts.

I have the honour to be with respect, my dear Sir, your Excellency's very humble and very obedient servant.

Baron Fourier, former Prefect of Isère.

Notes

(*a*) There is a marginal reference here to an address of thanks to Fourier from the principal proprietors of the land adjoining the swamps of Bourgoin for his part in the draining of these swamps.

(*b*) There is a marginal reference here to an attached copy of a letter to Fourier's successor as Prefect of Isère which proves the active steps he took to attempt to suppress any moves in Grenoble in favour of Napoleon.

1. Vaublanc, Vincent Marie Vienot, Count of (1756–1845). A pupil at the École Militaire in Paris he originally entered the army but resigned to become a member of the Legislative Assembly where he belonged to the Constitutional Party. He was a supporter of the monarchy though a decided liberal. He opposed the Girondins and defended Lafayette on 8 August 1792. On 10 August he owed his life to General Bertrand. He was not elected to the Convention and

escaped the Terror by wandering about from place to place. After 9 Thermidor he returned to Paris but was proscribed after 18 Fructidor (4 September 1797). He returned to France after the *coup d'état* of 18 Brumaire and became one of the most enthusiastic supporters of Napoleon. He was made Prefect of Moselle and continued in office after the First Restoration. During the Hundred Days he fled to Luxembourg and later joined the King at Ghent. He entered the Ministry of Richelieu as Minister of the Interior on 24 September 1815. He adopted a most reactionary policy especially towards prefects who had supported Napoleon in the Hundred Days and this earned him the approval of the 'chambre introuvable'. He was a favourite of the King's brother the Comte D'Artois. He was responsible for purgings of supporters of Napoleon from the Institut and he dissolved the École Polytechnique. His conduct became so intolerable in the cabinet that he was finally replaced on 8 May 1816 by Lainé (*Bio. Gen.; Gde. Encycl.*).

2. Marchand, Jean Gabriel (1765–1851). Before the Revolution he was a lawyer in the *parlement* of Grenoble and a friend of Barnave. Elected captain by the volunteers of the 4th Battallion of Isère in 1791 he fought through all the campaigns of the Republic in the armies of Italy and the Rhine. He distinguished himself at Jena and Friedland, in various engagements in Spain and Portugal including the battle of Busaco, and he fought in the rear-guard in the retreat from Moscow. He continued in his position under the First Restoration and refused to join Napoleon during the Hundred Days. He was court martialled in June 1816 for his failure to hold Grenoble for the king but was acquitted. He was created a peer of France in 1837 (*Bio. Gen.; Gde. Encycl.*).
3. A copy of this act is preserved in Fourier Dossier AN where it is listed as item 15 of the *pièces justificatives* to the present letter.
4. A copy of this order, in the form of a letter from the Comte de Chabrol, Prefect of the Rhône, is preserved in the Fourier Dossier AN. It is listed as item 16 of the *pièces justificatives* to the present letter.
5. A copy of this act is preserved in the Fourier Dossier AN. It is listed as item 18 of the *pièces justificatives* to the present letter.

XXVIII

Fourier to the president of the first class of the Institut

11 April 1816

To the President[1] of the First Class of the Institut

Mr. President Sir,

The Académie Royale des Sciences having proposed the election of several people as free *académiciens*,[2] I have the honour to express to you my desire to obtain one of these places. I presented myself to the members of the commission whose report must precede the election. I wished to entreat their goodwill and their vote personally. But several of these gentlemen were not to be found at home. I beg you to allow me to express in writing to the commission how grateful I would be if it were to include me on its presentation, placing me in the position which it deems appropriate.

I offered to the former Académie Royale des Sciences the results of my first researches in analysis. A report[3] was made on it twenty-six years ago by Messrs. Cousin[4] and Monge[5] who particularly desired to encourage my zeal. Since then I have not ceased to cultivate the sciences, and I have treated various questions in geometry, mechanics, and physics. I have often been diverted by other literary tasks or by civil occupations from the sciences, but my intention [now] is to consecrate myself entirely to them and to contribute to their progress to the best of my ability.

My attachment to science is in truth the only claim which I should advance to win your vote: but to some extent I am entitled to recall another which is very dear to me, since it was you yourself who awarded it: I wish to refer to the mathematics prize which the Institut was pleased to award for my researches on the theory of heat. I am in the process of publishing the work which will have about 480 quarto pages: 360 pages are already printed.

I beg you, Mr. President, to receive favourably and to present to the members of the committee the desire which I have the honour to express to you, and to receive with an equal kindness the homage of my respect.

With these sentiments Mr. President, Sir, I am your very humble and very obedient servant,

Fourier

Notes

1. Charles, J. A. C. (1746–1823). Experimental physicist.
2. As a result of Royal Ordinance of 21 March 1816.
3. No trace of this report is to be found in the archives of the *Académie des Sciences*.
4. See above, Letter VI, n. 4.
5. See above, Letter III, n. 3.

PROVENANCE OF LETTERS

LETTER	LOCATION	PREVIOUS PUBLICATION
I–IV	*Bib. Mun.* Auxerre MS. 335.	Challe (2)
V	*Arch. Yon.*	Quantin
VI–VII	*Bib. Mun.* Auxerre MS. 335.	Challe (2)
VIII	ANMSF^7. 4710.	Unpublished
IX	Fourier Dossier AdS.	Unpublished
X–XIII	*Bib. Mun.* Auxerre MS. 335.	Challe (2)
XIV–XVI	*Arch. Yon.* MS. 470.	Unpublished
XVII	BNMS ff. 22501 fol. 67, 75.	Unpublished
XVIII	*Ibid.*, fol. 66.	Unpublished
XIX	*Ibid.*, fol. 76–81.	Unpublished
XX	*Ibid.*, fol. 68.	Unpublished
XXI	*Ibid.*, fol. 72–73v, 74.	Unpublished
XXII	*Bib. Mun.* Auxerre MS. 335.	Challe (2)
XXIII	Fourier Dossier AN.	Unpublished
XXIV	*Bib. Mun.* Lyon MS. 2270.	Unpublished
XXV	*Ibid.*, MS. 2271.	Unpublished
XXVI	*Ibid.*, MS. 2272.	Unpublished
XXVII	Fourier Dossier AN.	Unpublished
XXVIII	Fourier Dossier AdS.	Unpublished

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Primary sources

Fourier's papers passed on his death to his friend Navier and ultimately found their way into the *Bibliothèque Nationale* where they are catalogued under MSS. ff. 22501–29. A summary list by content of these manuscripts will be found on pp. 496–7 of Grattan-Guinness (3). They are largely made up of mathematical and scientific writings, many of them drafts of published papers and works. All the letters in the collection are found in 22501 and 22529. The most important of these are reproduced in English translation in the Appendix of the present work as Letters XVII–XXI. In addition there are two sets of letters from Fourier to Sophie Germain in MS. ff. 9118 and MS. na. 4073. The *Archives Nationales*, Paris contain two major collections of manuscripts relating to Fourier. The dossier of the prefect Fourier (Fourier Dossier AN) MSF 1B1 160 contains a rich collection of material relating to Fourier's life in Grenoble and during the Hundred Days, much of it in the form of certified copies attached as *pièces justificatives* to various letters by Fourier in support of his application for a pension after his return to Paris in 1815. The second collection in the *Archives Nationales* is found in the series F^7 of the secret police relating to Fourier's second arrest in 1795 including the important letter to Bergoeing (Letter VIII). There are also certain other relevant manuscripts at various places in the *Archives* mostly relating to the Orléans affair and referred to above in Chapters 4 and 5. The Fourier dossier in the archives of the *Académie des Sciences* in Paris (Fourier Dossier AdS) contains a number of letters from Fourier including the very important letter to Villetard (Letter IX, Appendix) and in addition certain material relating to his election to the Académie. Part of his lectures at the École Polytechnique are found in the *Bibliothèque de l'Institut* (MS. 2044) together with a certain amount of other material. There is also a small amount of material relating to Fourier in the archives of the Académie Française. The original text of the 1807 memoir is contained as MS. 1851 in the archives of the École Nationale des Ponts et Chaussées, Paris. The same MS. contains an abstract (*extrait*) of the memoir together with a set of ten numbered notes referring to specific places in the text of this abstract.

The departmental archives of Yonne at Auxerre contain a particularly rich collection of material in section L relating to the Revolution in Auxerre. Thanks to a succession of devoted local historians including Quantin, Porée, and Forestier many of these documents and other related ones in the *Archives Nationales* and the Municipal Library of Auxerre have now been published. All the material on Fourier located in these manuscripts either published or unpublished has been incorporated in the present work. The Municipal Library of Auxerre also contains the precious collection of letters from Fourier to Bonard reproduced above in the Appendix. Lefebvre's *Études Orléanaises* contains an account of Laplanche's activities in Orléans in 1793, including some references to Fourier's intervention. This account was rendered doubly valuable by the destruction in 1940 of the documents on which it was based in the departmental archives of Loiret in Orléans. The departmental archives of Isère at Grenoble contain a large mass of material relating to Fourier's administration as prefect in Isère. This has not been drawn on directly in the present work as opposed to at second hand through extracts given in the writings of the various Champollion-Figeacs and those of Letonnelier. It would be necessary to make more extensive use of this material in a definitive biography of Fourier. Certain letters relating to Fourier's actions during the Hundred Days are located in the departmental archives at Lyons. These have all been referred to in the text. There are also a small number of Fourier letters at various municipal libraries in France including those of Amiens, Avignon, Grenoble, Nantes, and Versailles.

Fourier

(a) Major works and MSS. referred to in present work other than Letters reproduced in English translation in the Appendix. In each case the short title is given first.

Draft Paper	BN MS. ff. 22525, fol. 107–49 r and v.
1807 memoir	*Mémoire sur la propagation de la chaleur.*

Read in abstract before the Institut on 20 December 1807. The original memoir is preserved in MS. 1851 of the École Nationale des Ponts et Chaussées, Paris. The full text is reproduced with commentary in Grattan-Guinness (3).

Prize Essay	*Théorie du mouvement de la chaleur dans les corps solides.*

The winning entry for the 1811 Prize competition of the Institut on the subject of the propagation of heat in solid bodies. The original manuscript is preserved in the archives of the Académie des Sciences. Page references are to the version of the essay published in two parts in the *Mémoires de l'Académie Royale des Sciences.* (vol. 4 (1819–20); 185–555, 5 (1821–2), 153–246). The second part of this publication is given in *Oeuvres*, 2, 1–94.

Historical Précis	*Précis historique de la propagation de la chaleur.* BN MS. ff. 22525 fol. 152–68 r. and v.
Analytical Theory	*Théorie analytique de la chaleur*, Paris 1822.

Page references throughout will be to the version published in *Oeuvres*, 1.

Oeuvres	*Oeuvres de Fourier* (Ed. G. Darboux, 2 Vols.), Paris, 1888–90.
Fourier Dossier AN	AN MS. FIBI 160.
Fourier Dossier AdS	Dossier of J. B. Fourier, *Archives de l'Académie des Sciences*, Paris.
Historical Notes	BN MS. ff. 22529 fol. 102.

(b) Other works and MSS.

The full title and/or location of all other Fourier works or MSS. referred to in the present work are given in the notes. For an extensive list of Fourier's published works see Grattan-Guinness (3), pp. 491–5.

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The general history of Auxerre and neighbourhood, including certain relevant details of the revolutionary period, is given in Challe (3), Chardon, Henry, Lebeuf, Phélipeaux, and Pinsseau. Challe (1), Cestre (2), Moiset, and Schmidt give a well-documented account of the history of the *Collège d'Auxerre* especially during the period 1789–1804. The general background to the Benedictine teaching order of St. Maur is given in the article by Lemoine in Taton (3), which is also useful for its bibliographic references including that to Tassin. The main sources for Fourier's early life up to 1798 are Cousin, Mauger, and Arago. Cousin's account is largely based on first-hand witnesses. It stands up well to comparisons with other, primary sources of information and must be judged a most reliable, careful, and scholarly account. It is also much the most extensive and detailed account. Mauger's account, though much shorter than Cousin's, and possibly influenced by Cousin, is nevertheless valuable as coming from a friend of Fourier's, and for certain details not found elsewhere. Arago's *éloge*, though lively and well written, evidently depended for various details on Cousin, and has its value reduced still further by a total lack of documentation. Among the many histories of the French Revolution, some excellent, Soboul and Lefebvre (1) proved particularly useful for setting Fourier's life within the general framework of the Revolution. Of more specialized works Egret was particularly valuable for the so-called Aristocratic Revolution, Aulard (2) for the early effect of the Revolution on the religious orders, Sirich for the changing role of the revolutionary committees of 1793, Lefebvre (2) for the background to Fourier's intervention in Orléans, and Lefebvre (3) for the Thermidorian reaction. For the role of science in the saving of the Republic in 1793–4 Biot (4), Fayet, and Pouchet were particularly useful, for the short-lived École Normale of Year II, Allain, Barnard, Fayet, and the *Notice historique*, and for the foundation of the École Polytechnique, Allain, Barnard, Fayet, Fourcy, Pinet, and the *Livre de centenaire*. For Fourier's life in the period 1793–5 Cousin is the best secondary source, followed by Mauger and Arago in that order. Apart from two brief references in Fourcy and a few lines in Cousin and Arago there appears to be nothing on Fourier's time at the École Polytechnique in 1795–8. Herold, who frankly confesses his dependence on the definitive work of La Jonquière, provides an excellent general account of the Egyptian campaign and many interesting details on the Cairo Institute. Of the many other works on the subject listed in Herold's bibliography those by Bainville and Charles-Roux are outstanding. For Fourier's part in the Egyptian campaign Cousin and J. J. Champollion-Figeac are the most important secondary sources, and the same writers in company with A. L. Champollion-Figeac and Letonnelier provide a wealth of information on the prefect Fourier, much of it of a documentary nature. Dubreton and Artz—which contains an extensive bibliography—were useful for the general background to the First and Second Restorations. For Fourier and the Hundred Days Champollion-Figeac is the main source followed by Cousin who also provides almost the only source for Fourier's last years in Paris from 1815 onwards.

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